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OFFICE OF NAVAL RESEARCH
LONDON

# EUROPEAN SCIENTIFIC NOTES

ESN 31-5

31 MAY 1977




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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's European Office of Aerospace Research

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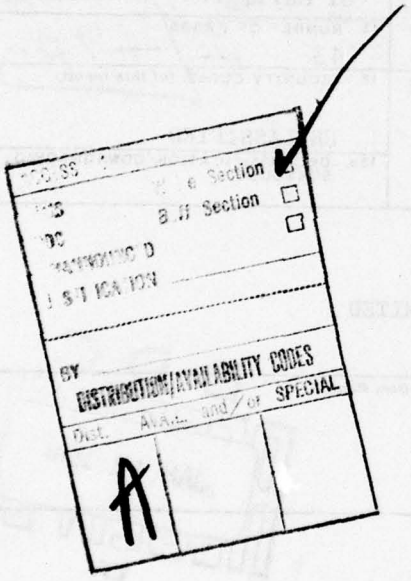

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# OFFICE OF NAVAL RESEARCH
# LONDON

Edited by William J. Gordon and Victoria S. Hewitson

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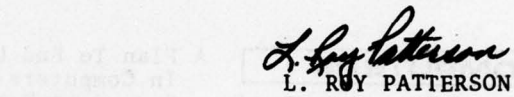
Scientific Director



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# BIOLOGICAL SCIENCES

## THROUGH THICK AND THIN TO MEMBRANE ELECTROCHEMISTRY AT ORSAY

The twenty-ninth international gathering of the Société de Chimie Physique (Université de Paris-Sud, Orsay, 12-15 October 1976) devoted itself to the question of electrical phenomena at the level of organization of biological membranes. The distinguished committee, presided over by Dr. E. Roux of the Centre d'Etudes Nucléaires de Saclay, may or may not have experienced sensations of intrepidity in ushering their organization into the fashionable society of the membrane couturiers and their customers, but by so doing they at least managed to side-step the electrical basis of all molecular and atomic interactions, on the one hand, and to steer clear of the pure and applied electrobiology of whole organisms, on the other. This, however, left them seeking admission to an interface much overpopulated by recent journal coverage, symposia and monographs and, even with a novel approach in mind, a certain temerity was needed to energize the operation.

The approach, novel or not, was nowhere explicitly stated, nor did the sequence of papers reflect a clear pattern, but from the identities of the authors and the topics expounded one supposes that the intention was to expose physical chemists to some of the facts of life as represented by excitation, photosynthesis and vision, and to examine physicochemical systems, mostly constructed from materials of biological origin, which may assist in the understanding of these basic living processes.

Seen as an expression of this presumed structure, the meeting was both a qualified success and a disappointment. There was an evident wish to mingle the quick with the dead by having some of each in every session, in the belief, I suppose, that propinquity would generate fruitful interdisciplinary exchanges. The result was not perhaps as discouraging as that noted on another occasion (J.H. Schulman, *ESN* 30-10:456), but in the absence of exceptionally well-informed interdisciplinary guidance from the chair, the questions and comments tended to be limited to the individual papers and to come from the respective specialists. The expert in one field who rashly ventured into another often asked naive questions which could not well be dealt with without delaying the progress of the meeting, while the speakers themselves, with one or two notable exceptions, displayed no eagerness to depart from the kind of presentation that they would give (and indeed had probably given several times already) to their specialist confreres. One of the naive questions was: "How can potassium conductance take place in pores which bind potassium?" Another, persistently and vociferously posed: "How can you justify use of the Nernst equation for concentration cell EMF in membrane systems which are not in equilibrium?" Well, plausible mechanisms for the first do exist. As for the second, a quick pragmatic answer will do: it works, so sometimes.

I hope that some of these impressions will prove to be misleading when the published proceedings, including questions and answers, appear from Elsevier in the near future. It will be interesting at a later date to compare the result with that of the more logically organized conference, covering much of the same ground, offered by the New York Academy of Sciences, 26-28 January 1977. A similarly watertight approach, if adopted at Orsay, would have made it difficult to include such a suggestive paper as that of Mme. M. Dupeyrat and Mlle. E. Nakache (Univ. Paris VI) demonstrating interfacial turbulence related to certain electrogenic local variations of interfacial tension, for example, at the boundary between a solution of potassium iodide in nitrobenzene and an aqueous solution of octadecyltrimethylammonium chloride--undeniably a somewhat "non-biological" system. On the face of it, the phenomenon is no closer to life than the model of nerve transmission described long ago by R.S. Lillie: an electrochemical wave of depolarization that travels along a passive iron wire when the protective film is locally "stimulated": but it is certainly thought-provoking. Several other examples of the work of the French schools which were not heard in New York gave the meeting a special interest for foreign guests.

International meetings, even when internationally organized, have to reflect the geographical and financial realities associated with their setting. Last year's International Biophysics Congress was overwhelmingly peopled by Danes of whom only a very few actually gave papers. The Orsay meeting, organized by a provincial society (in the international sense) was predictably parochial in make-up, 16 of the 40 papers, or 40%, being from French laboratories. Not only that: 14 were from the Paris area, two from Montpellier in the south of France, and none at all from the rest of the country. France's immediate and most scientifically active neighbors, Germany and the Netherlands, fared better than the French provinces, with 3½ and 5 papers respectively; Great Britain, separated by water, with only 2; Belgium, the stronghold of irreversible thermodynamics, with 1; and Italy, Switzerland and Spain with exactly 3 times zero. From second and third neighbors east of the twelfth degree of longitude, we had Hungary and Yugoslavia, 1 each, and the USSR, 2--a pair of whom neither turned up. One each from Israel and Japan. And that is all, save for (I nearly forgot) what the corn-flakes advertisers would call a whopping US contingent giving 5½ papers and doing their fair share, or more, of the general talking.

The French contributions, as I have said earlier, gave one a chance to appreciate their areas of particular excellence. The international circuit was represented by J.P. Changeux (Inst. Pasteur, Paris) who predictably gave a *déjà entendu* but nevertheless splendid account of his work on synaptic transmission by acetylcholine. Then there was E. Rojas, now at the Ecole Normale Supérieure, with a highly volatile exposition of his work at Cambridge and Plymouth on the gating mechanism of the sodium channels in nerve. French research on photosynthesis was represented by P. Joliot (Inst. de Biologie Physicochimique, Paris) and by G. Paillotin and M. Michel-Villaz from the very important team working with E. Roux at Saclay. Joliot talked about vectorial electron transport in photosynthetic membranes in the context of papers on other aspects of the same phenomenon during a morning session devoted largely to photosynthesis. The Saclay people presented some theoretical calculations of electric fields in dielectric membranes generated by photosynthetic charge separation. It was a pity, perhaps, that some of the recent experimental work from Saclay could not have been given on this occasion. For the rest, the French papers were a testimony to the strength of the schools of electrochemistry and surface chemistry among a generation influenced by Monnier, Dervichian, Guastalla and Joly. The inclusion of two papers from Montpellier while the rest of provincial France was ignored reminded us of the presence there of a very good CNRS group for research on the physical chemistry of interfaces.

The German papers dealt with ion channels in biological membranes, with the exception of a talk by the prolific H. Witt (Max Volmer Inst., Berlin, FRG) who supported exhaustively his contention--not universally accepted--that the light-induced transmembrane potential in photosynthetic membranes causes ATP production. He put this to the test experimentally, with apparent success, by showing that an applied potential bypassing the photochemical machinery can also cause ATP to be formed.

The two papers from the UK were excellent but limited in scope. B.L. Ginsborg (Univ. Medical School, Edinburgh) provided a welcome excursion into strange territory with his work on dopamine release by the salivary gland of the cockroach. R.H. Tredgold (Univ. Lancaster) put forward an energetically acceptable model of ion-transmitting polypeptide pores in lipid bilayers and offered experimental support derived from measurements of electric properties of dry polypeptides and of bilayers containing gramicidin.

Finally, with no intended discourtesy to the authors of the remaining "minority" papers, a word about those from the US. Probably because one has to be very selective when inviting people to travel 6000 miles, *hin und zurück*, to give a paper (even with the benefit of modest support from the US Army's European Research Office), the US speakers were outstanding. Between them, they covered a fair acreage of disciplinary and interdisciplinary ground, and they showed a special aptitude for placing their own work in perspective. C.P. Bean, well known as a research associate working since 1951 on solid state physics at General Electric Corporate Research and Development (Schenectady, NY), introduced

electrical fluctuation theory via the Coulter counter and amused us with his statistics in support of the dubious proposition that one may induce longevity by engaging in the study of fluctuations. Solid state physics was also represented by two contributors already well known for their fundamental studies in this field and for their active contributions to biophysics. J.J. Hopfield, Professor of Physics at Princeton University since 1964, reviewed electron transport between biological molecules, referring specially to his prediction of a new weak infrared absorption band arising from electron tunneling in cytochrome c and proposing a most ingenious way of demonstrating it experimentally. W.W. Webb, Professor of Applied and Engineering Physics at Cornell University (Ithaca, NY) since 1965, gave an impressive talk on the use of fluorescent probes to measure lateral transport in membranes. S. McLaughlin (State Univ. of New York, Stony Brook, NY) discussed the effect of adsorbed ions in modifying the electrostatic potential of membranes and thus altering the uptake of hydrophobic molecules possessing charged end groups. Finally, as the sole American photobiologist present, A. Lewis (Cornell Univ., Ithaca, NY) showed how recent methods of resonance Raman spectroscopy and picosecond emission- and absorption-spectrophotometry have led to considerable modification of our ideas about the early events in visual transduction. Not that everything has become crystal clear: indeed, Lewis gave plenty of ground for confusion, but obfuscation, whether intentional or inadvertent, could not dim the brilliance of the experimental approach.

I daresay this report is a bit more fragmented than the meeting it purports to describe, and undoubtedly rather biased. On the other hand, it is safe to say that the ideal confrontation between the *in vivo* and the *in vitro* experimenters, with their different areas of specialization and their immiscible jargons, did not take place, so that I do not feel too blameworthy for failing to integrate the unintegrated. This was not the first symposium of its kind, and it will not be the last, to fall short of realizing the impeccable intentions of its creators. We should be grateful to them for eliciting some stimulating papers, for providing the setting for lively discussions, and for enduring the arduous working period between inception of the idea and its implementation. A summary of the meeting's technical content will appear as ONRL Conference Report 3-77. (J.B. Bateman)

## LEUCOCYTE CULTURES IN GERMANY

The 8th Workshop on Leucocyte Cultures was held in West Berlin 2-5 March 1977. The meeting is organized on an annual basis by various German researchers. This year the organizing committee consisted of R. Averdunk, T. Diamantstein, K.E. Gillert, J.L. Age-Stehr, H.R. Maurer and H. Ruhl, all of West Berlin. The meeting brings together European research and clinical immuno-biologists and fosters an exchange of current ideas and new research techniques. This year about 300 people attended. Although two-thirds of the scientists were from Germany, the vast majority of papers were presented and discussed in English.

I will summarize some of the more interesting papers and add relevant background material when necessary.

One of the most exciting papers was presented by H. Lemile and G. Hammerling, who work with Prof. K. Rajewsky in Cologne, Germany. They described recent advances in cell fusion technology. The currently used techniques for cell fusion are those described by Kohler and Milstein [*Nature* 256, 495 (1975)]. In this process two cells are induced to fuse together, making a new hybrid cell that contains two nuclei, one from each of the original cells. The agents used to induce the cells to fuse include inactivated sendai virus or polyethylene glycol. The group from Cologne have been fusing mouse myeloma cells (tumor cells that continuously secrete antibody) with normal antibody-producing cells from mouse spleen tissue. While the antibody produced by the myeloma cell is not specific for any antigen, the antibody produced by the normal mouse spleen cells will be directed towards whatever antigen with which the mouse had been immunized. When the two types of cells are fused, the resultant hybrid now continually secretes

both the myeloma antibody and the specific antibody of the normal mouse spleen cell. By immunizing mice with selected antigens and removing spleen cells for fusion at the appropriate time, it should be possible to prepare hybrid cells capable of continuously producing antibody to virtually any antigen one wishes.

The researchers at Cologne have now prepared hybrid cell lines making antibody against lysozyme, staph nuclease, sheep red-blood cells, Streptococcus A, and a small chemical determinant known as NIP. Since the hybrids can grow either in tissue culture or in animals, and continuously secrete antibody, an easy method is provided to obtain enormous amounts of highly specific antibody.

The whole concept is especially relevant to the production of protective antibodies against toxins or other pathogens. We currently have no methods to produce large amounts of human antibodies except by immunizing volunteers, which strictly limits the kinds of antitoxins that can be prepared. It is certain that these fusion techniques will soon be applicable to the human myeloma cells, and the technology for inducing normal human cells to make specific antibody in tissue cultures is now appearing in the literature. The combination of these two techniques should provide us with methods of making large amounts of human antibody against virtually any antigen we wish, whether it be toxin, virus or bacteria. This protective antibody could then be injected into anyone at risk, conferring on him a state of passive immunity.

A paper presented by L. Hertzenberg (Stanford, California), who is now working in the laboratories of C. Milstein in Cambridge, England, described similar advances with cell fusions. They are, however, carrying the procedure a few steps further. Using tumor cell lines derived from thymus cells (T-cells), they are trying to produce hybrids that secrete some of the biological mediators, known to be made by T-cells, that provide signals between cells. These factors have been extremely difficult to isolate; however, using these fusion techniques it may be possible to prepare enough material for detailed analysis. It is interesting to note that the current level of research on T-cell factors is at a similar stage as the research into antibody molecules was about 20 years ago.

Ulrich Hammerling (New York) presented a great deal of information about techniques employed in inducing lymphocytes to mature, using various chemical agents. The long-term goal of his work is to be able to take primitive cells from the bone marrow and by using various chemicals, induce them to mature and become antibody-forming cells. He finds that many agents such as lipopolysaccharide, or prostoglandins increase intracellular cyclic AMP (adenosine monophosphate) and cause the cell to mature to a stage just prior to antibody synthesis. Actually to induce the cell to become a plasma cell and produce antibody requires a different signal. He makes the suggestion that certain agents give "go" signals to the cell, depending on the stage of maturity of the cells, while at a different stage, the same agent may give a "stop" signal; hence, to go from primitive to mature antibody-forming cell requires a series of correct signals to the cell. This is relevant to studies of certain diseases where cells producing harmful antibodies are present. If one could discover what constitutes an "off" signal for the cell producing harmful antibodies, it might be possible to modulate the immune response beneficially.

The final interesting paper was presented by M. Taussig (Cambridge, England). It is well known that for cells to mature and become antibody-forming cells in animals a number of different cell types must successfully interact and provide the right antigen specific mediators or signals. T-cells (coming from the thymus gland) seem to be the ones controlling whether a B-cell (bone marrow cell) is allowed to mature to a plasma cell and eventually secrete antibody. The T-cell, when stimulated by an appropriate antigen, controls this process by secreting certain factors or biological signals. Taussig has been studying these T-cell factors for a number of years and has postulated that certain B-cells have acceptor sites for the T-cell factors. He has found that his mouse T-cell factors also are active in other mammals, such as rabbits and, surprisingly, humans. He suggests that the

acceptor sites for these T-cell factors have been preserved during evolution and speciation.

In a series of experiments he was able to show that only 60% of normal humans have B-cells with acceptor sites for certain of the T-cell factors. This immediately suggests that to have an acceptor site one must possess an appropriate gene or cluster of genes that control the production of such acceptor sites. He has also found that those who lack an acceptor site are also incapable of making the specific antibody response, the broad implication being that some people fail to make antibodies to certain vaccines because they lack the appropriate genes and hence acceptor sites on their cells to receive the T-cell signals. Taussig has been able to map the site of the genes that control the production of acceptor sites for two separate T-cell factors. These kinds of genes are called Immune Response genes (IR genes) as they control the ability to produce an immune response (see *ESN* 31-3:117). This is the first good evidence for IR genes in humans. As more work like this is carried on it may become possible to predict who will respond to certain vaccines and who will not.

In all, the meeting was well organized and the increased level of sophistication of the work, as compared to the past two years, is most impressive. (LCDR James N. Woody, US NAVACTSUK)

## CHEMISTRY

### CENTENARY OF THE ROYAL INSTITUTE OF CHEMISTRY

The Royal Institute of Chemistry celebrated its hundredth anniversary on 28 March. The ceremonies in London featured a talk by Sir Harold Wilson, former Prime Minister, who recalled with some nostalgia that the Institute was born during "the spacious years when Disraeli was Prime Minister, the years of Britain's naval supremacy and diplomatic power; 1877 was the year before the Congress of Berlin, when he came back rightly claiming to have brought back 'peace with honour'."

The Institute grew out of the older (1841) Chemical Society, and is the only chartered professional organization in the UK empowered to grant certificates of competency to persons engaged in the profession of chemistry. The Institute has other functions ranging from an advisory body on professional chemical qualifications to government departments, universities and business establishments to an almost union-like function as a negotiating body with these same groups on matters relating to the conditions of employment of chemists--their salaries, status, health and welfare. About five years ago steps were taken to amalgamate the 29,000-member Institute with the Chemical Society, the Faraday Society, and the Society for Analytical Chemistry. A partial unification was achieved and negotiations are now underway that are expected to complete the process by 1980 to give a united organization covering approximately 40,000 members.

From Sir Harold's speech--the usual blend of seriousness and humor, national self-congratulation and self-reproach, history and prognosis which British public figures concoct *par excellence*--the following excerpt, dealing with an address by the Marquis of Salisbury at the Golden Jubilee of the Chemical Society, provides some amusing perspectives on the progress of chemistry.

"I don't know who briefed Salisbury," Wilson said, "but he was a bit sniffy about benzene.

> 'Why is benzene so famous? Why is she lifted up among so many of her compeers who appear in the chemical lists with formulas as imposing and with histories quite as difficult to follow? It is that the products drawn from benzene, or at least from coal-tar, have had the good fortune to produce colours which catch the female eye....But I plead for her humbler sisters who have produced no colours, but the study of whom may yet be steps to the discovery of mighty laws and phenomena which may interest the world.'

He was on less secure ground when he wrote off the atom. Referring to what chemistry was when he was a young man, he went on:

> 'In those days the atom reigned supreme; but now the atom has been dethroned and the bacillus reigns in its stead.'

Well, as we know, the atom managed to make a comeback, and we haven't heard the last of the bacillus, either." (James H. Schulman)

## COMPUTERS

### A PLAN TO END US-JAPANESE DOMINANCE IN COMPUTERS AND ELECTRONIC COMPONENT TECHNOLOGY?

The Commission of the European Communities, also known as the European Economic Commission (EEC), has recently disclosed its blueprint to support selectively European electronics and informatics industries. If approved by the Council of Ministers this spring, funds worth 103 million units of account, about $75 million, will be pumped into these industries between 1978 and 1981.

A brief article in the News and Notes section of *ESN* 31-2 announced the existence of the EEC plan. This article describes significant aspects of the plan in greater detail and discusses its potential impact on the industry as a whole.

The electronics-informatics industry is the fastest growing (16% per annum) industry in the world today. By 1980 it is predicted by some observers to become third largest and, by 1985, the largest industry in the free world. Since its products are a part of, or support, virtually every other industry, it is of vital importance to an industrial country's economy. It is for these reasons that the EEC is proposing to invest most of its development funds into industrial R&D programs which will put its member countries into strong competitive positions with the US and Japan.

The areas where the Commission is proposing to fund specific R&D projects include: applications software, a real-time programming language standard, peri-informatics hardware, and integrated circuit technology. To complement these projects, the Commission is also planning to undertake a series of studies and support efforts in the areas of standardization, public procurement, data confidentiality-security, software protection, data processing research and education, and data processing impact on society.

Support for R&D under the Community scheme provides for assistance in the form of financial aid up to a maximum of 50% of the total project costs. Categories of efforts which come under the aid scheme include feasibility studies, pre-development studies, and developments. In the case of feasibility studies, support may be extended to 100% of the actual costs. Activities eligible to receive project aid include users of data processing (associations, etc.), producers of hardware and software, electronic component manufacturers, and the Community itself in the form of support for studies and reports.

Specific projects being supported or proposed in the applications sector include a preliminary study of a data bank for matching organs and blood, a legal information data base, computer-aided design studies, and an import-export data base. Other application areas where proposals are being considered are transportation, the environment, natural resources, documentation, and office automation.

The real-time programming language project has received publicity in connection with its similarity to the US Department of Defense (DOD) High Order Language project which is much further advanced (request for proposals are being issued this spring). The EEC effort has yet to be approved (also expected this spring) and will involve a two-year effort to define a prototype language and specification (similar to the DOD "Ironman", the successor to "Tinman" and earlier language requirements documents).

Under the category of portability the EEC is proposing to support development of a European Systems Language (ESL) (some overlap in capability with the real-time programming language project), a portable operating system for European mini-computers, programming language conversion aids, transaction processing programs which are compatible with diverse data banks, and data-base management programs. Most or all of these applications will be implemented in ESL to allow maximum portability between various types of computers.

The peri-informatics industry (micro-computers, intelligent terminals, mini-computers, and turnkey data processing

systems) are growing at almost twice (30%) the rate of the electronics-informatics industry as a whole. Investment in these areas, the Commission feels, will allow European industry to compete with the flood of such devices being developed in the US for worldwide distribution. In this area, it is possible to develop application-specific devices which meet European industrial and consumer requirements. This is especially true of devices which interface directly with an operator where Europeans tend to require a higher level of human engineering.

Integrated circuit technology is probably the area where Europe is the farthest behind giants in the US and Japan such as: Texas Instruments, Motorola, Fairchild, RCA, National Semi-Conductors, Hitachi, and Toshiba. Even with Philips and Siemens, Europe provides only 14% of world production for its low 23% of world consumption. To improve its position in production of electronic components, the Commission proposes to support joint efforts in VLSI (very large-scale integration) similar to a national program in Japan, application-specific microprocessors, and advanced solid state memory technology (charge-coupled device, magnetic domain, and holographic).

The European blueprint for ending US-Japanese dominance in the electronics-informatics industry is contained in Commission of the European Communities Report COM(76)524 Final Vol. I-IV, Brussels, 29 October 1976. That report and the author's personal knowledge of the industry provide the basis for this article.

Some recent events which make the blueprint seem less likely to succeed in all aspects are the acquisition of Singer (US) computer interests by International Computers, Limited (ICL) (UK) and the establishment of a joint-venture computer peripherals company in the UK by Control Data Corporation, NCR Corporation and ICL, Ltd. These events have tended to contravene the EEC's efforts to allow development of a wholly European peri-informatics industry. The multi-nationals don't appear to be following the EEC's blueprint because they stand to realize a larger share of the world market if they think and act globally rather than on a national or regional basis. Support and studies in the areas of standards, research and education, social impact, and software protection, however, have a better chance of succeeding because of their relatively lower costs (last year IBM alone spent over $130 million on R&D) and wider acceptance by the various industry participants. (LCDR D.C. Rummler)

## ELECTRONICS

### ELECTRONICS AND HORNETS' NESTS MEET AT TEL-AVIV UNIVERSITY

Experiments performed recently at Tel-Aviv University show that the comb-building activity of hornets is strongly influenced by the ambient magnetic field. In fact, adult hornets (more than 3 days beyond eclosion, i.e., beyond emergence in their final form as imagines) are not able to adapt to a field several times that of the earth; they become motionless and die. Younger hornets, too, remain motionless for several days but then commence normal activities in a modified manner, building smaller combs of different structure and cell orientation. Thus, hornets join migrating birds, dancing bees, and certain beetles and ants in using the earth's magnetic field (of the order of 0.4 gauss) to guide their activities, but the organs that enable them to do so have yet to be discovered.

Jacob Ishay (Dept. of Physiology and Pharmacology, Sackler School of Medicine, Tel-Aviv Univ.) has been studying hornets' comb-building for a number of years and has been joined recently by Professor Moshe Kisliuk (Dept. of Electronics, School of Engineering, Tel-Aviv Univ.), whose own recent research interests have involved the magnetization of ferrite bodies of arbitrary shape immersed in nonuniform fields and the oblique incidence of a plane electromagnetic wave upon an anisotropic layer. In 1975 Kisliuk came to Israel from Leningrad, where he had worked on degaussing in the 1950s at the Naval Development Office. Because the University's Department of Electronics is located in the Medical School's building, it was convenient for Kisliuk to collaborate in

this research, supplying the 100 x 28 x 28 cm helix of square cross section in which to place the hornets' breeding boxes. To get a nonuniform field, some breeding boxes were placed next to the helix rather than inside it.

Hornets' combs ordinarily hang downward from a short stem-like pedicle, but in a uniform 23-gauss horizontal field oriented along the magnetic meridian the hornets build no pedicles, and the combs are attached to the walls rather than to the ceiling of the breeding box. Only hornets that enter this field in the pre-imagine stage survive more than 3 days, but the larvae they raise in the small, crude combs do not survive the fifth instar, i.e., the fifth molt of the larva.

Hornets that enter a uniform field of 1.3 gauss as juveniles (1 to 3 days after eclosion) survive no more than 7 days but are able to begin normal comb-building, although the cell orientation ranges between 6° and 30° from vertical rather than the normal 6° to 14°. The comb consists in this case of 20 to 60 cells instead of the normal 20 to 200 or the 1 to 8 resulting from the 23-gauss field, but the larvae again do not survive the fifth instar.

In the nonuniform field outside the solenoid ranging from 0.3 to 0.6 gauss, the longevity of juveniles is normal, but they do not engage in comb-building. Those hornets that enter the nonuniform field in the pre-imagine stage produce pedicles in a variety of upward directions, however, instead of vertically downward, and the 1 to 60 cells of their combs tend to point in the direction of decreasing field. In this case the larvae survive the fifth instar, but most of them die before eclosion.

It is interesting to compare these results with those Ishay obtained earlier by the use of a centrifuge with vertical axis. Adult hornets introduced into the altered gravitational field built their combs downward, but juveniles introduced into this field followed the direction of the resultant of gravity and centrifugal force. It thus appears that the adults normally have learned to make use of the earth's magnetic field in orienting their combs, but they cannot adapt to a change in it. Juvenile and pre-imagine hornets survive the change in magnetic field perhaps because they have not yet come to depend on the earth's field.

All of the experiments were carried out along with controls subjected to the same handling and temperature change but without the change in magnetic field. It is not clear why the altered magnetic field should be lethal for the larvae nor why the alteration produces a few days of inactivity in imagines, but it is evident that hornets are considerably influenced by fields of the order of the earth's. Kisliuk suspects that the mechanism through which they sense this field is electronic paramagnetic resonance.

The Medical School and the Electronics Department are linked not only by geography but also by virtue of the second hat worn by Prof. Julius L. Goldstein, head of the latter Department since 1976, who is also Professor of Medical Electronics, and who came to the University from MIT in 1973. His research centers around hearing, speech, and color vision. Currently he is measuring the intermodulation frequencies (IMF) produced in the ear by a two-tone stimulus, the IMF being the sum or difference of the frequencies of the two tones. For this purpose he introduces a third stimulus tone whose frequency is near the IMF being measured, and he asks the subject to notice the beats between it and the IMF. By means of a fourth stimulus tone at the latter frequency he is then able to cancel out the intermodulation. Its intensity seems to vary much less rapidly as a function of the strengths of the original two tones than one might expect. Work on this phenomenon continues with the aid of digital equipment that permits the subject to control the intensity and phase of the fourth tone and to ask for a paired repetition of the stimuli with and without it.

The Electronics Department has 20 faculty members and 400 undergraduates in its 4-year engineering program, which begins at an advanced level, as well as 125 graduate students (only a quarter of them full-time) working for the MSc and PhD. Altogether, Tel-Aviv University has 15,000 students, having grown rapidly in recent years as a center for those within commuting distance. Except for engineering, its undergraduate programs take 3 years.

The research interests of the other Electronics Department faculty members cover a wide range broadly divided

into physical electronics and systems engineering. The former includes electrical discharges, plasma physics, and electro-optics, as well as semiconductors, thin films, and solar cells. The Department's research in systems engineering ranges from control theory to estimation and prediction, communication systems, and related topics, such as the production and transmission of speech. There is also medical electronic research related to clinical treatment and monitoring of patients and to the enhancement of x-ray, thermal, and other medical images. Professor N.W. Rosenberg's work on this last topic extends to the analysis of images of the earth's surface obtained from satellites and airborne sensors in order to study agricultural patterns of land use, water resources, pollution, etc.

It is to be hoped that this large amount of interesting interdisciplinary work will continue after the Department of Electronics moves into its own building in 1979. (Nelson M. Blachman)

## GENERAL

### PROBLEMS AFFECTING ACADEMIC RESEARCH IN ISRAEL

"When a poor man eats a chicken, one of them must be sick." This aphorism is typical of the wry Sholem Aleichem-type humor with which Israelis address their multitude of problems. The "poor man" talking was a physicist at one of Israel's leading universities, who said that the austerity measures imposed on academia (*ESN* 31-2:40) had persuaded him to buy the "sick chicken"--an unproven spectroscopic instrument--principally because of its low price. He ruefully reported that he had not managed to make a single measurement with the equipment after spending months fighting with it and with the manufacturer. This scientist was able to buy some equipment, at least, and hence was a lot better off than many of his colleagues on the same campus and other Israeli campuses, where cuts of 65% in academic budgets were mentioned, cuts so severe as to leave an academic administration little for research after paying salaries.

The primary cause of the cuts was the economic problems created by the Yom Kippur war, which led to the devaluation of Israeli currency and to the over 20% inflation. The cuts also, perhaps, represent an intensification of the government's policy of weaning universities away from government-supported basic research and of encouraging academics to pay more attention to fields of economic and technical interest to the State, particularly those fields that enhance Israeli industry. This policy is not new, for the Israeli Government has long felt that its economic salvation lies at least in part in the direction of "science-based industries" and has offered various "carrots" in the form of "science-based industrial parks" near universities, as well as specialized research centers and institutes to encourage industrial R&D. But the decrease in university budgets is the "stick" the government is constrained to wield along with the "carrot".

The response of the academic community is predictable; it is a replay of the debates, this time in an Israeli context, on socially relevant research vs basic undirected research that have earlier wracked US and European society. The "carrots" have been only moderately successful, because it is easier to talk glibly about science-based industry in general than to come up with specific ideas that can compete in foreign markets against industrial giants of the developed countries. Moreover, both the tempo and the depth of technical understanding of the Israeli bureaucracy leave much to be desired when it comes to underwriting technical enterprises. Some academics see the budget "stick" as a triumph of anti-intellectual hostility or, at the very least, shortsightedness. Most people in universities, however, appear to accept the situation with grim realism, although they bemoan its effects, and everyone tries to cope as best he can.

At the University of Tel-Aviv, for example there are extensive computing facilities wisely acquired during the "days of plenty"; senior staff members with international connections exploit this excess computer capability on contracts with US groups (sometimes through the Israel-US Binational

Science Foundation) or through other national or international oraganizations. The reputations of many of the Tel-Aviv staff make them very welcome members of research teams at major international facilities such as the Rutherford Laboratory, CERN, and DESY (the Deutsches Elektronensynchrotron in Hamburg) with their major facilities for high-energy physics. Institutions like the Technion, which have been closer than most universities to Israeli defense and to civilian industries and thus have considerable experience in contracting for applied research, find the situation harder than usual but not an entirely new ball game. The older universities, moreover, have a backlog of equipment and technologists to carry their momentum for a little while longer. But the outlook for the younger scientist just getting started in newer universities in fields requiring expensive sophisticated instrumentation is very bleak.

These economic frustrations add to the problems already alluded to in the *ESN* article cited above, i.e., the three-year delay for military service before students enter the universities, a delay which usually stretches into four or five years because they have become officers. In addition, faculty members called up for their annual tours of active service have to drop their work where it is and report for duty; exemptions for the difficulty or inconvenience of research interruption do not exist. Thus, a large part of a student's most productive years of research is lost, and there is much interference with research progress even for the more mature investigator.

Another general difficulty facing students in Israel is the fact that the textbooks and references used in universities are usually in a foreign language, such as English. This, of course, poses an opportunity as well as a problem. At a more advanced level, the student and teacher both find it necessary not only to read but also to write in a foreign language in order to publish papers that will be read abroad. Finally, there is the problem posed by the financial necessity of taking on more than one job, such as additional teaching while working full-time at another university or in an industrial or government laboratory. This extra work is widely felt to reduce productivity in the primary job and to result in wasted time traveling between jobs that are often in different cities.

There are perquisites, however, that often help to eke out the Israeli professor's salary--such as a book allowance, a gasoline allowance, subsidized housing, and a generous sum that is accumulated for sabbaticals and is not taxed if the sabbatical is spent abroad. With the aid of a salaried sabbatical post, an Israeli scientist can save this sum to tide himself over until the next sabbatical. This system accounts in part for the extraordinary amount of contact between Israeli scientists and foreign institutions, which has been instrumental in the building up of science and technology in Israel.

The 2% monthly inflation of the Israeli pound (*ESN* 31-4:152) causes prices to rise steadily, leading Israelis to borrow all they can and to spend it immediately. As a result, Israel appears to be much more prosperous than she really is. It is still a developing country, impoverished by the need for devoting 40% of her GNP to defense (Egypt, by comparison, spends 44% for this purpose, which comes to only one-tenth as much per capita), and is able to pay only a small fraction as much for salaries as do the developed countries. Nearly all Israel's professors, nevertheless, return from their sabbaticals abroad, eager to continue their efforts to build up their country and insure its survival. (James H. Schulman and Nelson M. Blachman)

## ELSCINT--AN ISRAELI SCIENCE-BASED INDUSTRY

It isn't often that someone remembers details of lectures that you gave a decade ago, but I had the pleasure of meeting such a person, Dr. Avraham Suhami, President and General Manager of Elscint, Ltd., a Haifa company which manufactures sophisticated electronic equipment for research and medical diagnosis. Suhami was still at the Technion in 1966 and attended a Summer Course, organized that year by the late Professor Emmanuel Estermann to promote interaction between Israeli

industry and academia, at which I lectured on luminescence, color centers, radiation effects in solids and radiation dosimetry. (One of the other lecturers was Dr. David Brandon, who remained to head electron microscopy, x-ray fluorescence and similar work at the Technion.)

One of the field visits the group made during that seminar was to the Elron factory in Haifa, situated in a converted private dwelling. I still remember my amazement at seeing the production line, where Yemenite immigrant girls were engaged in such culturally foreign activities as soldering electronic components for educational computer kits. Elron was one of the few Israeli concerns a decade ago that felt any kinship with academia. It is now a major holding company in the electronics area, Elscint, Ltd. being one of its affiliates. Suhami indicated that the 1966 Technion course of lectures had done something to influence his consideration of an industrial career, and this was further promoted by discussions with Estermann himself. After taking a flyer at it in 1968, while still retaining his association with the Technion, he decided that this was the life for him and joined Elscint full-time in early 1969.

In Israel the success of a company is measured in large part by its export earnings. For Elscint these were under $500 K in 1969; by 1975 they had grown to more than $6000 K, and Suhami is predicting a much greater export volume for the coming year. I talked with him about the techniques that made his company successful, asking his views about the effectiveness of the steps that the Government has taken to encourage science-based industries (such as electronics, electro-optics, computers, pharmaceuticals), one of which is its promotion of "science-based industrial parks" in the neighborhood of universities. This led to questions on the general Israeli R&D situation, particularly on the major decreases in the budget allocation for university research.

As for the first subject, Suhami emphasized the importance of the fact that all of his management at Elscint were trained as scientists or engineers, with subsequent training in business matters. The success of Elscint comes from having such people at the top and from keeping the chain of decision-makers as short as possible, with each of them familiar with the full range of his role (science-technology, technology-engineering, engineering-production, production-marketing, marketing-business economics). This, Suhami admitted, was easier to do as a company grows from small beginnings up to the present level of Elscint (approximately 2000 employees) and gets harder to do with further increasing size. Suhami feels that the science-based industrial parks are not an important factor, and might even be irrelevant to the problem of attracting academic people to applied industrial research. The Boston "Route 128" configuration, in his opinion, was the product of American scientific entrepreneurs in universities who had also learned something about management and were backed by venture capital. Interested, active people had produced the contiguity of these enterprises around universities, he said, but it does not follow that the converse will be true.

In response to my question about how a small technology-based company can keep from being overwhelmed by competition, and what roles market research and industrial secrecy play in preventing this, Suhami replied that he is not keen on either market research or secrecy. He is convinced that if he and his upper echelon associates can't sense what is needed or wanted, they aren't going to be saved by so-called market research. Having decided what product to put out, he believes that a company ought to get its first design on the market as fast as possible and use its initial customers as its most valuable critics and market researchers. It is much better strategy to make continual 10% improvements, in response to diagnoses and demands from the field, than to accumulate responses over a long period of time and attempt to make a 100% improvement in the second model. Not only is this procedure more desirable from the standpoint of keeping the company's name and activity before the public, but it avoids another peril: even technically able managers can go astray, Suhami said, because they and their associates can mistakenly convince themselves they are on the right track unless they get steady feedback from customers. Thus, continual contact with the market and

incremental improvements in response to it is the way to go.

Concerning the research and education picture, Suhami feels that the decrease in the Israeli university research funding could be a blessing in disguise if handled right, i.e., by making vertical cuts rather than shaving everybody a bit horizontally. For example, he feels that Israel is too small to carry out research in every field of science, and that the replication of research efforts in several universities with groups of less-than-critical size is to be deplored. There should preferably be one or a few large clusters of effort rather than dispersed minimal-size groups working in the same field. He indicated, furthermore, that the choice of fields and facilities to invest in must be made with these considerations in mind, even when the funds are donated from abroad. Some choices can be counterproductive, encouraging a generation of young Israeli scientists into fields that may have no major scientific payoff in view of overwhelming worldwide competitive facilities, let alone no practical economic payoff. Suhami recognizes the prestige appeal of erudite basic research--an appeal which is heightened by the traditional Jewish worship of scholarship--but he feels that this should be the domain of a select body of highly qualified researchers, and that the larger community of scientific and technical workers should not consider applied work as less challenging or noble.

As for the present and the future of Elscint, the company turns out an impressive array of medical diagnostic equipment--gamma cameras, x-ray tomographic equipment (about whose performance and export potential the company is extremely proud), and a highly sophisticated computer system for storing and displaying diagnostic information (including color-processed x-ray images) for large populations of clinic and hospital patients. At this point, Elscint has reached a critical stage in some respects. To adhere to the management principles enunciated by Suhami, any expansion that takes place must concentrate on a limited number of new products, which would involve large capital investment in R&D and in engineering at this stage of the company's size, as opposed to the smaller developments upon which the organization has grown in the past. The large amount of venture capital now needed is not readily available in Israel for a combination of reasons, one of which is the apparent lack of familiarity with science and technology in Israeli investment circles. But on the basis of the technical ingenuity, hard work, and good sense of the Elscint management, the prognosis is good. (James H. Schulman)

## EGYPT: LAND OF THE PAST--AND OF THE FUTURE?

What is Egypt? A land of pyramids, a land of Aswan Dams, or a land of doctors? An enigma. We are familiar with all three aspects, the pyramids from childhood, the Aswan Dam from recent political events, and the doctors we have seen more frequently in our towns and hospitals across the US. Our ignorance is being swept somewhat aside with increasingly numerous television interviews with a personable and nattily attired President Sadat, with the treasures of Tutankhamen visiting us, and we might even very mistakenly equate Egypt with colorful Arab sheiks we hear about so often. But, why do we have so many Egyptian doctors in the US--in fact, professionals of every class, many of them with a national and international reputation?

The professionals have come to us because they fit into our society with little difficulty since their education has not been so different from our own, with English as the university language of instruction, and most importantly, because the overwhelming population growth of the lower classes has made life increasingly frustrating and difficult for everyone in Egypt. Catering for the ever-increasing numbers of the poor and uneducated or ill-educated leaves little opportunity to have the "good life" that education is supposed to promise. While we Americans have been leading a relatively comfortable life in the past few decades, I have been given the strong impression by Egyptians themselves that life stood still in Egypt under President Nasser while he pursued his dreams of greater Arab glory and paid little attention to the creature comforts of the people. While they spent

their energies and their lives in Yemen and in other battles, nothing else was done in Egypt and time really did stand still there. The telephone system, for example, is still the identical one of some 40 or 50 years ago. Wires are rotten, and telephone conversations are so unreliable that no modern society could survive--a phone call is a matter of chance, and is regarded as such. Apparently, Nasser felt that nationalism and socialism would solve the ills of the country--but they didn't, and the ills were compounded by the exponentially rising population, a severely limited national income, and a horrendous military budget.

The population of Egypt is almost 90% Moslem, the remainder being mainly Christian. In the religious sense, Egypt is a very moderate country, and it follows Moslem custom in that Friday is the Holy Day. Government offices work on a six-day week, every day except Friday, from 0800 to 1400 without a break, that is, 36 hours per week. During the six-hour working day, no meals are taken, and, as far as I could tell, survival comes from frequent cups of tea or coffee, liberally laced with sugar to give the needed energy. Such working hours give some leeway to the busy and ambitious man, in effect, to hold down more than one job, and this may also be a matter of mere survival since salaries are ridiculously low.

It becomes a bitter and vicious circle--it seems that Egypt educates its citizens so that they can emigrate--doctors, engineers, mechanics, whatever--after a while they start to balance the desire everyone has to live in one's mother country against the physical creature benefits of living somewhere else where the pay is right, and things work.

But, why even discuss Egypt; we have so little to do with it. To the contrary, Egypt has become increasingly important to the US in recent years in seeking a political solution to the problems of the Middle East. Our Embassy is reopened and, according to Addison Richmond, our personable young Science Attaché there, has over a hundred cooperative research projects underway between the US and Egypt. Many of them date to earlier times, since, contrary to what we may have imagined, scientific contacts continued all these years even when we had no real diplomatic relations. (The American University in downtown Cairo never suffered because of the antagonisms of the respective governments. In *ESN* 30-9:403, some aspects of education and research in Egypt were touched on.) Perhaps most important are the PL-480 funds that make these cooperative programs possible. Egyptian currency is non-convertible, and while she has been paying the US for many goods and services over the past two decades, it has been in her own currency so that a tidy sum has collected. One way of spending this is to use it on cooperative research. (These Special Foreign Currency Programs have existed in the past with a number of countries, although Egypt is one of the few to have an active program at this time.) The National Science Foundation, on behalf of the Dept. of State, is the official US government agency for managing these funds for research purposes, although the Agency for International Development has very large programs of its own underway.

Few Americans realize that there is a tremendous pool of educated scientists and engineers available in Egypt who would be more than happy to work on a cooperative basis with a stateside scientist. While it is true that conditions in universities tend to be crowded, this applies more to the teaching areas than to research possibilities, although it does cut down somewhat on the professor's available time. Nevertheless, the laboratory equipment available for research is of a relatively high quality, in many cases very modern, and although really exotic projects probably can't be carried out, most research can. Some of the advantages of such cooperative research are: First, the fact that NSF has reviewed and funded a joint US/Egyptian proposal gives the Egyptian colleague the knowledge that he is contributing to part of the world scientific scene. Secondly, the research must have the dual objectives of being useful and important to both countries. The Stateside scientist has the important incentive of designing a program in which, because of the really low salary scales that exist in Egypt, he can really get a lot for the money.

I personally spent some weeks in Egypt recently in connection with a PL-480 research project on low-cost

housing that I am directing--it is a cooperative project and my Egyptian partner is the "General Organization for Housing, Building, and Planning Research", which is in the Cairo suburb of Dokky. The words "General Organization" could be confusing, since this is a particular government designation defining the level of the agency; indeed, there are a number of General Organizations. Unfortunately, I did not receive a clear picture of the Egyptian government organizational plan; but, as I understand it, a General Organization is rather independent and has the opportunity to be entrepreneurial.

My host, the General Organization for Housing, Building and Planning Research (GOHBPR), was established almost two years ago, from what was the Building Research Institute. The Chairman of the new organization is Dr. Mostafa El-Hifnawi, an extremely energetic and masterful leader probably in his early fifties. (He has the attributes which I would presume must be necessary for a position of leadership in Egypt as he seems to have the universal admiration and respect of his large staff.) Like many Egyptians with a scientific or engineering background, he followed his undergraduate training in Egypt with doctoral studies in Europe--he has a PhD in civil engineering from St. Andrews University in Scotland. A dynamic man, clearly overworked as are all of Egypt's leaders, he has had a varied background--scientific attaché in Vienna and London, vice-president of Greater Cairo's planning commission, member or chairman of numerous national boards and committees, and head of the Egyptian delegation to the UN on Habitat, to name but a few. To cap it all, he is still a professor lecturing once a week for some hours at Ain Shams University in Cairo!

The Organization is divided into 14 technical divisions whose titles reflect their objectives. Each division has a head and can be relatively independent, depending on the personality of the head. Particularly intriguing for me was the fact that so many of the really good researchers and research managers whom I met also held professorial positions at a local university. This is officially encouraged, in fact, since it reflects on the value of the man and also on the worth of the General Organization.

The General Organization presents a good picture, both outside and inside. From the outside, it becomes obvious that its building is divided into three parts, a six-story central office and small laboratory block, flanked on one side by a small auditorium, and on the other by a large laboratory block where full-scale experiments can be conducted, and where smaller specialized laboratories surround the main floor. The large laboratory complex is in the process of being doubled in size, and the auditorium is not quite finished. There is also an outdoor testing area, but, in the past few years, other government organizations have had their laboratories built nearby so that this area has lost most of its usefulness. Inside the crowded laboratory the testing equipment is very much up-to-date, much of it being from Eastern Europe. Because of the crowded conditions, some of the equipment is still unpacked, in some instances for 15 years! Time takes on a different meaning when there is absolutely nothing you can do about it except to accept the inevitable--and apparently this is part of the Moslem spirit which enables one to accept today's worries by looking forward to tomorrow's joys.

My first tour of the building was conducted by Dr. Mostafa El-Demery who is head of the laboratories, and also head of the Soil Mechanics Division. We started with the main laboratory floor--which looked like a modern structural testing laboratory anywhere in the world. It contained large testing areas that looked like a dynamic testing bed but actually was a static one (a dynamic bed was under construction in the addition), and all kinds of familiar machines: for instance, a 500-ton Amsler static machine, a 100-ton Losenhausen dynamic machine, a MAN torsion machine, and a host of others. All this is serviced by an overhead 10-ton crane. Most, if not all, of the tests underway on the main floor were on various concrete elements such as beams, roofs and floor systems. These were mainly industrial tests with only some limited structural research underway.

I spent a considerable time with Dr. Mohamed Ramez, Head of the Raw Materials and Processing Department. A personable, dynamic, and direct

young man, he is concerned with any and all raw materials for industry and is making bricks from shale and from various by-products. (The Aswan High Dam has created some difficulties in the construction industry since little silt is now available for bricks, as it was traditionally for millenia with the flooding of the River Nile.) Ramez feels that his group is among the world leaders in the development of the new shale-fired bricks: he noted their use of calcium silicates as stabilizing agents. I was impressed by research he has underway on lightweight aggregates. This work has led directly to the building of a factory to utilize the new procedures.

We discussed many aspects of manual vs factory production, and particularly the part that quality control is playing. But, there is the other side of the coin--in fact, it is a vicious circle. Traditional brick is made by thousands of workers, yet its manufacture must be stopped since it uses up valuable silt needed for agriculture, and also because the traditional methods result in really poor and weak bricks. Yet, the loss of jobs by these workers would be catastrophic, and would lead to severe social problems.

The Soil Mechanics Laboratory, under Dr. El-Demery, is the biggest one in all of Africa, and it looked it--even more impressive when I learned that much of the most modern equipment is still unpacked waiting for the laboratory expansion to be completed.

The Acoustics Laboratory has really excellent equipment. The Danish electronic equipment by Briel and Kjoer is less than a year old, and enables both model and full-scale tests. On-going studies include sound measurement in houses, auditoria, and airports, with both field and laboratory measurements. New construction materials are routinely checked for sound transmission properties.

The Thermal Laboratory, which seemed to me to be most important for a country with such blisteringly hot summers, has a drastic need for equipment, so much so that most of the work is theoretical. Dr. George Hanna, in charge of the Thermal Lab, explained to me how he estimates the temperature response of buildings by the use of a digital computer--he predicts the variation of temperature in a building due to people, the sun, single or double facade, and the like. He tries to make the people in a building comfortable--whether this is by orientation, shuttering, color of walls, cross-ventilation at night, whatever--and if nothing else will work, he indicates the need for air conditioning. (Incidentally, "comfortable" is defined as 22-27°C and 50% humidity.) One of his current studies, for the Ministry of Culture, is to determine how inside temperature and humidity interact.

Certainly, Egypt is walking a very tight rope in feeding and housing its millions and in making plans for a decent future. Egypt has had a glorious past, and the moderation of its present leaders and the entrepreneurship and abilities of its middle and top management could lead to a pleasant and confident future. (Lambert Tall, Lehigh Univ., Bethelehem, PA)

## COMMON SENSE ABOUT COMMON SCIENCE IN THE COMMON MARKET

On 24 March, one day before the twentieth anniversary of the Treaty of Rome which established the European Economic Community (EEC) and the European Atomic Energy Community (EURATOM), Dr. Gunther Schuster, Director-General of the EEC for Research, Science and Education marked the imminent anniversary by a lecture "Towards a Common Research and Science Policy in the European Community" at the Institution of Electrical Engineers in London.

A major anniversary is a traditional time to assess the performance of an organization. There can be no disagreement concerning the magnitude of the EEC's accomplishment in reducing the ancient impediments for travel of people and goods between its nine member countries, which now form a single "Common Market" of over 250 million people, free of customs barriers and import duties. The implementation of a common agricultural policy is also considered to be a most remarkable piece of integration.

The oil crisis which confronted the world in 1973 and the well-known problems that resulted from it have threatened many of the EEC's achievements and goals, however. Critics allege that there is a return to nationalism and protectionism, at least in

some EEC countries; that the Community as a whole has no overall economic, monetary, industrial, or energy policy; and that its machinery (a Parliament, a Council, a Commission, and a Court of Justice) is too cumbersome and is dominated by the national interests of the member countries.

It was within this less-than-exhilarating atmosphere that Schuster gave his talk, and these circumstances undoubtedly account for its down-to-earth tone, which stressed the practical realities of achieving cooperation between the different countries of Europe in scientific research. Schuster pointed out that only in 1974, 17 years after the Treaty of Rome, was the decision taken to develop a common policy with regard to science and technology in general, as distinct from a common policy just for nuclear energy. This broader effort is therefore in its infancy.

The EEC research and science policy is dedicated to the support of the main objective of the Community, namely, the survival of the countries composing it. In its most elementary sense, survival requires an assured energy supply, an assured supply of raw materials, and a viable and prosperous agriculture. In a broader sense it calls also for economic growth and development, improvement of the physical health of the population, urban development designed to give a good quality of life, and an acceptable environment. Schuster defined EEC R&D policy to consist of three things: (1) the definition of common objectives, (2) the realization of these common objectives by joint action, and (3) the coordination of national research efforts.

In the light of the above guidelines, EEC *research activities* will be pursued only where EEC *policies* already exist (fields such as agriculture, energy, etc.) and where EEC R&D activities will not compete with existing national or international programs. (Even when there is general Community interest, it is considered better to ask national facilities to do the work if the subject is already of interest to the individual nations.) Lastly, the EEC will carry on research on subjects that (like fusion power) are so expensive that a single nation cannot afford the research effort; or that require a larger market to make the product worth developing than any one nation can offer; or that, by their very nature, are transnational (international transport, communications, etc.); or where it makes sense to promulgate EEC requirements or specifications (the environmental field, for example, where the pollutant content of air or water is concerned).

Schuster conceded that the EURATOM Joint Research Center [the collective name for the establishments at Ispra (Italy), Karlsruhe (Germany), Petten (The Netherlands) and Geel (Belgium)] had not lived up to expectations, perhaps because of its charter limiting it to the nuclear energy field and because of conflicting national interests. But now this Center has had its mission redefined and broadened to include the investigation of new energy sources, hydrogen as an energy vector, the environment, and nuclear safety and waste disposal, and Schuster was optimistic about its prospects for the future.

He was far less sanguine--even somewhat grim--about another matter related to the Joint Research Center, namely, the Joint European Torus (JET), the EEC venture in nuclear-fusion power research. The repeated failure of the Council of Research Ministers to agree on a site for JET is well known (see *ESN* 29-9:388 and ONRL Report R-25-75); there have been five fruitless meetings on the subject in the last eighteen months, and the political maneuvering for this "plum" has been fierce. Schuster would make no prediction concerning the action of the Council which was due to meet again within a few days to attempt to settle the matter. (As it turned out, the Ministerial meeting on 30 March dissolved in a bad-tempered deadlock, and at the present moment the whole JET project based at the UK's Culham Laboratories, near Oxford, is in danger of collapsing as a result.)

The EEC employs a number of different mechanisms ("modalities") to implement its science research policy:

(1) Direct Actions: intramural research within EEC establishments, financed completely by the Community and run entirely by its personnel;

(2) Indirect Actions: projects carried out extramurally in member countries' laboratories, supported 50% by EEC and the remainder by the institution involved (the above-mentioned fusion research is an example); and

(3) Concerted Actions: wherein the EEC at Brussels identifies and coordinates a program which is run and financed by national groups.

Schuster pointed out that member countries often provided additional indirect incentives such as depreciation allowances, tax preferences, etc., to encourage R&D.

Schuster's Directorate encounters difficulties which are peculiar to international bodies like the EEC. First of all, the science/technology objectives of member countries vary considerably. Secondly, their science/technology management philosophies vary even more widely. For example, in France there is centralization of R&D management (*ESN* 39-6:282), while in the UK there is dispersal of responsibility [via the customer-contractor principle, the determination of departmental programs by their own Chief Scientists, etc. (*ESN* 30-8:373 and ONRL Report C-19-75)]. The coordination of work in nine different countries run by such drastically different managerial methods is extremely difficult. Moreover, each country often has strong preferences as to which of the various "modalities" discussed above should be used, even when the need for the R&D is agreed upon. Third, there are hangovers from the past, i.e., bilateral agreements and institutions such as the European Space Agency (ESA). For example, because of the existence of ESA, the EEC has no role to play in space at all. Finally, from the point of view of an EEC official, there is still another problem. The Community is based on three specific treaties, and every time something is proposed, Schuster has to leaf through all three of the treaties to determine whether action by his Directorate is permitted or not.

Schuster next discussed the zoo that comprises the so-called "Jungle of Committees" in Brussels. Within any national community there are typically two types of committee: one composed of individual experts and another type composed of experts that represent particular institutions, such as professional societies or government establishments. In the EEC these are overlaid by still another set of committees representing the governments involved. Moreover, there are different committees to advise the component parts of the EEC--the Council of Ministers, the Commission, the Parliament, and the Court of Justice. Although Schuster tried to impress his audience by listing the welter of committees, their acronyms and their respective roles, I found their number and overlapping functions neither more nor less terrifying than those which exist within a single country, such as the US.

Turning to the coordination of national R&D efforts, Schuster asked, "What fields are amenable to coordination?" He distinguished basic research, applied research funded by governments, and applied research funded by industry. The EEC has concluded that it should not, and hence it does not, attempt to coordinate basic research. It also cannot coordinate research within private industry. This leaves only applied research funded by governments that it can try to coordinate. The coordination consists of getting information from the Member States concerning the areas of work, the projects being undertaken, the budgets allocated to these projects, and disseminating this and related information within the EEC. When individual nations are doing the same kind of projects, Schuster's Directorate attempts to coordinate the actual division of labor. Schuster pointed out that the funds allocated by the governments within their national program areas far exceed those made available for Community allocation. Some perspective on the role of the EEC in European research comes from the fact that during the interval 1970 through 1976, the EEC was given only 1% as much money to spend on R&D as its Member States did individually. It is interesting to note that the Member States spent much more than this, a total of 10%, on other international cooperative R&D (such as CERN). The present share of the EEC in European R&D has recently been increased somewhat, however, and will be approximately $380 Million between now and 1980.

One measure of the vitality of European research is a comparison of the number of researchers in the EEC Member States with those in other major areas of the world, viz, the US and Japan. The numbers of academic research professionals are roughly as follows:

| Country | Number | Per Capita |
|---|---|---|
| EEC | 285,000 | 1.1 ($10^{-3}$) |
| US | 510,000 | 2.4 ($10^{-3}$) |
| Japan | 239,000 | 2.2 ($10^{-3}$) |

By this criterion the European community is not doing well at all.

Taking the energy area as an example, Schuster illustrated the detailed formulation of EEC R&D policy. The objective is to ensure energy sources for the future. This requires a reduction of dependence on oil imports, a reduction in energy use of 1% per year, and a better distribution and utilization of available resources. (The reader should remember that this European view was expressed well before Pres. Carter's addresses on the US energy problem.) Schuster emphasized that oil and gas will essentially be depleted around the year 2000, and that there is now a great deal of public opposition to nuclear energy. To cope with this situation the EEC R&D policy is as follows:

(1) Encourage research to promote intensified production of domestic fossil fuel;
(2) Carry on research for nuclear power;
(3) Conduct research on new sources of energy;
(4) Develop substitutes for oil by coal conversion;
(5) Find a substitute for electricity as an energy vector (i.e., hydrogen);
(6) Conduct research on energy conservation.

All of the above R&D actions should be consistent with the preservation of the environment.

The priorities in these areas are: for the near-term, conservation, coal modification, and the use of nuclear fission; for the medium-term, geothermal, coal gasification, and solar power; and for the long-term, solar power, the breeder reactor, and fusion. Cutting across all of these is the consideration of hydrogen as the energy vector. Consideration is also being given to the biomass approach as an energy source. Schuster pointed out that what the US may do with regard to nuclear waste reprocessing, in the interests of anti-nuclear proliferation, may cut the ground out from under advanced nuclear systems in Europe, hence US decisions are extremely important to Europe.

Besides the energy question, Schuster's Directorate is dealing with R&D problems connected with raw-materials supply, the environment, industrial innovation, life in society, town and country planning, and medicine. Some discussion has been held concerning the EEC's need for a forecasting organization. Although this need is appreciated, the EEC is currently reluctant to establish a new and costly organization.

Schuster's attempt to be realistic in his description of the problems facing the EEC Directorate for Research, Science and Education seemed to provoke a pessimistic response in his UK audience, whose members have been grappling for some time with a deteriorating R&D situation in Great Britain (*ESN* 29-3:138; 29-4:196). One question from the floor, which was more a dirge for Europe than a question, asked Schuster if Europe could ever hope to draw even with the US in view of the statistics given in the talk, inflationary problems, and the mismatch between educational systems and industrial needs. Schuster's "chin-up" reply was that things were by no means as bad as all that. Europe, he claimed, is ahead of, or at least competitive with, the US in chemistry and it is ahead in nuclear energy--the only working fast-breeder reactor in the Western world is in France. He conceded, however, that Europe was definitely well behind the US in computers and aeronautics, and that how Europe could forge ahead in these and other fields was indeed a serious problem for the EEC. (James H. Schulman)

**ONRL REPORTS**

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## MATERIALS SCIENCES

### SPRAY-ROLLING: A NEW METALS TECHNOLOGY?

The production of thin strip is a major concern in the metal industry. Spray-rolling, a recent approach to strip production, provides a new approach which potentially combines production economy with material improvement.

The common approach to strip production is casting and rolling of ingots. This requires a loss of the sensible heat of the melt on solidification of the ingot, expenditure of substantial energy in rolling the ingot, expenditure of energy for intermediate heat-treatments, and significant cropping losses. As an alternative, direct rolling of metal powders has been explored. There are difficulties here, too: the production of suitable powders is expensive, rolling speeds are reduced by gas efflux, pre-sintered strip is difficult to handle, etc.

A.R.E. Singer (University College, Swansea, Wales) has pioneered a method which appears to combine the strengths of each of these methods. In spray-rolling, liquid metal (or alloy) is atomized with an inert gas ($N_2$, most commonly) and sprayed directly onto a substrate. This is reminiscent of splat-cooling (which it basically is) with the major difference that spray-rolling utilizes greatly reduced cooling rates, intentionally. In splat-cooling, little reduction in melt temperature is suffered in flight; in spray-cooling, the preferred condition appears to include some solidification in each droplet, enroute to the substrate. In splat-cooling, the substrate is maintained cooled, so that the sensible heat of the droplets become an "evil", to be extracted and disposed of as rapidly as possible; in spray-cooling, the sensible heat is extracted and used to maintain the substrate (i.e., the roll) at an elevated temperature to assist in subsequent strip consolidation and thickness reduction. (The as-deposited strip has a 15-20% porosity.) Despite the slower cooling rate, spray-rolling retains--albeit less dramatically--the ability to deposit alloys in extended solid solution, well beyond phase-diagram limits. Furthermore, thick layers (e.g., 1 cm) can be sprayed.

The droplets used in spray-rolling are ~100 μm diameter. They are flattened on impact, so that the microstructure is dominated by elongated particles, which become the nuclei of the grains of the strip. This structure is appropriate for subsequent rolling, reducing rolling energy requirements still further.

Singer has concentrated primarily on aluminum and aluminum alloys. He has compared a spray-rolled Al-Fe-Ni alloy ("E") with the same alloy in the conventional wrought condition (RR58). In the spray-rolled condition, the room-temperature ultimate tensile strength (UTS) of E was 20% greater than the UTS of RR58, with similar elongations. After one week at 200°C, the UTS of E increased a few percent; the UTS of RR58 decreased by a similar amount. The UTS of both alloys decreased on holding at 300°C for one week, but the UTS of E was over twice that of RR58. The admission of a controlled small amount of oxygen to the spray chamber allows the possibility of further grain-size control with little deterioration of mechanical properties (actually, an increase in strength) and at no additional cost. Retaining a fine grain-size at elevated temperatures, through intentional oxidation, opens the possibility of developing superplasticity.

Composite metals can also be produced. Intimate deposits can be realized by co-deposition of two (or more) insoluble phases. The short times involved guarantee uniform distribution of phases. In fact, mutual solubility may be inconsequential in such a co-deposition process. Singer and coworkers have successfully demonstrated the capacity of co-deposition techniques with silicon carbide in aluminum. Laminar composites are also possible by depositing separate strips on individual drums, then running these strips through common reduction rolls. Bonding is good.

Metal tubing can also be produced by spray-rolling. In a direct extension of strip technique, the outside surface of a mandrel, which is both rotating and translating, is sprayed. Consolidation of the "green" tubing is through reeling or swageing. For

tube production, the strength of spray-rolling lies in the fact that thin tubes, the most difficult tubes to make by conventional techniques (which start from thick-walled materials), can be made in a straightforward manner by spray-rolling.

What, then, are the difficulties in spray-rolling as a technique and its introduction into industry? The crucial requirement on the technique is uniformity of deposition thickness across the width of the strip, to a very few percent or better. Clearly spray-nozzle blockage is intolerable; in fact, high nozzle reliability is the basic condition, one not achieved without full attention to detail. Assuming proper nozzle performance, it still remains a non-trivial matter to guarantee uniformity, particularly over wide strip sections, while minimizing edge losses due to over-spraying. One approach calls for the use of a rapidly oscillating nozzle. The current approach, used in a demonstration experiment in industry, uses multiple nozzles. Green strip, 20 in. x 24 ft, has been produced with acceptable thickness tolerance.

Acceptance of spray-rolling for the plant floor requires the demonstration of technique (now in process), demonstration of scale-up, more complete economic analysis, and--perhaps most difficult--acceptance of a substitution to long-standing technology. With high investment in current plant capital equipment, the lapse of considerable time for full acceptance seems inevitable. The situation could be accelerated or altered by the demonstration of enhanced material properties (e.g., through extended solid solution). Yet properties investigations of these materials are largely non-existent as yet. (A. Sosin)

**ONRL REPORTS**

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## VAPOR-DEPOSITION AND ELECTRON-BEAM PROCESSING--TAKING THE LOW VACUUM ROAD

In the quest for new and improved surface treatment methods, surface technologists have been drawn toward higher vacuum (HV) technology by the prodigious recent advances in HV equipment and almost a faith that more pristine environments must bring better coatings with them. The work of R.A. Dugdale (Atomic Energy Research Establishment, Harwell, UK) points in a different direction.

For some years, Dugdale has worked with electron beam (EB) processing. His successes in this endeavor have led him to more recent development of vapor deposition, using his EB techniques as a basis.

EB processing of materials started with Pirani at the turn of the century; he applied a simple glow discharge gun to melt Ta. Concentrated development of EB technology is more recent, dating back only about twenty years. In fact, EB technology waited for the preceding development of HV technology, since HV ($10^{-4}$ to $10^{-5}$ Torr) technology was required for the high-powered electron beams to provide for adequate lifetime of metal (W or Ta) filamentary cathodes. The expense of HV technology in production has led to the use of low vacuum (LV) environments in the target regions, while HV conditions, achieved by differential pumping, are maintained in the filament region. In effect, Dugdale has taken this full circle by returning to LV ($10^{-3}$ to 1 Torr) techniques entirely, by moving away from filamentary cathodes to glow discharge sources for the generation of electron beams. These beams may be used directly for welding, for example, in a variety of manners and with adjustable geometries, described below. Alternatively, EB may be used to heat a source for the evolution of metallic or ceramic vapor. As still a further variation, Dugdale uses deposition from a sputtering dc cathode.

Is a move "back" to LV an act of regression? Clearly pumpdown time and, concomitantly, access time may be increased by avoiding HV. The question then really becomes whether the cleanliness generally associated with HV is sacrificed. In many cases, the answer is no. If the residual

molecules in the vacuum (typically gases) are condensible, suitably disposed surfaces can shield the sample from them. If the molecules are non-condensible, these "processes gases" may be swept away by a preselected ambient gas toward the vacuum pump. Thus, gassing from the sample surface and via vacuum pump back-diffusion can be controlled by the use of judicious equipment geometry and the high mass pumping speed of LV technology. Inert gases are obvious choices as passive ambient gases, but other gases can be employed with possible advantage (e.g., the use of H in selected heat-treatments of metals) or because they are intrinsically necessary (e.g., in chemical vapor deposition--CVD).

In some applications, the use of HV technology may actually not be permitted. CVD is one such example. Another involves deposition of vapors which precipitate in the gas phase during transport in HV. Homogeneous precipitation becomes more unfavorable at elevated gas temperatures. If the goal is to produce fine powders, low temperatures are, therefore, in order; indeed, this method forms the basis for the production of extremely fine ceramic powders. In surface deposition work, however, fine powders are an anathema. Optimal conditions can frequently be achieved by passing to somewhat elevated temperatures (e.g., 200°C) and LV condition.

In EB processing, Dugdale achieves his working conditions primarily through the design of the deposition system geometry and with the use of a glow discharge source. These are sketched in Figs. 1 and 2.

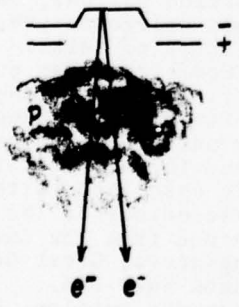



Fig. 1

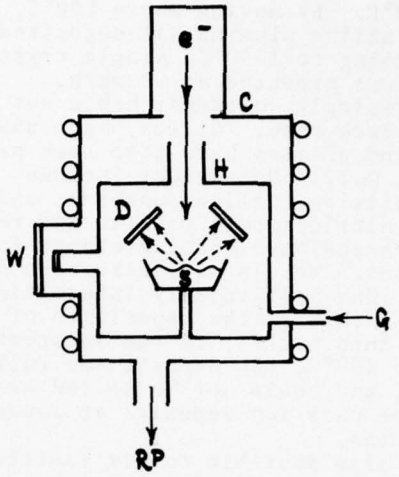



Fig. 2

The electron beam ($e^-$) is extracted from the plasma (P) region of the source in Fig. 1 and impinges on the vapor source (S) of Fig. 2. The working region, H, of the apparatus is maintained warm while the outside container, C, is cooled. Clearly the deposition substrates, D, can be maintained at selected temperatures, as well. Gas admission, G, rough pumping, RP, and observation access through windows, W, are provided in straightforward manners. Notice that the vapor is supplied in a broad solid-angle region providing a "high throwing power", an aspect which can be either an advantage or disadvantage, depending on application and design. Notice also that the design provides for effective blocking of back-diffusion and that condensible vapors are retained on the inner chamber by the high aspect ratio of the vents.

The depositions achieved by Dugdale are most impressive. His earliest soft vacuum depositions were oxide ceramics. Finding the optimum deposition parameters proved to be no inconsequential consideration. Thus a tough, well-bonded, stress-free amorphous alumina ($Al_2O_3$) coating was produced by deposition in high purity (99.999%) hydrogen gas; a little oxygen in the gas produced a stressed deposit which cracked on cooling from the deposition temperatures, generally

below 700°C. By moving above 800°C, polycrystalline alumina was deposited and, on going to 1400°C, single crystal sapphire was produced at ∿1 mm/h. Not surprisingly, columnar habit was found in each case. Silica, magnesia, spinel, and glasses have also been produced, as well. Non-oxides include silicon nitride, silicon carbide, and titanium nitride; both passive and reactive schemes have been developed for these cases. Metals have also been deposited. One particularly interesting example of this is the deposition of aluminum onto nickel; if the substrate was above 400°C, the deposit was fully adherent, and could not be peeled away as was the case for deposits at lower temperatures.

It is also possible to mix families. Metals can be deposited onto ceramics in a very effective manner. Similarly, ceramics or glasses can be deposited onto metals. The latter operation is the easier, since thermal expansion coefficients should be well matched in the former case whereas some mismatch can be allowed in the latter--due to the fact that the non-metallic deposit is under compression on cooling to room temperature and this does not lead to the break-up that a tensile stress would tend to induce.

In some cases, EB vapor-deposition is unfavorable due to marked differences in vapor pressures, as in the case of the deposition of refractory metal alloys. In these cases, Dugdale uses a dc-sputter cathode in place of the electron beam. This is an electrode which generates vapor under ion bombardment in a glow discharge. Sputtering permits the transfer of materials from the source to the substrate with little or no variation in composition, generally. However, sputtering rates are usually slow compared to evaporation. With the availability of two source types, a very wide range of deposits is clearly available.

Returning to the plasma-induced EB techniques, again, Dugdale and coworkers at Harwell have developed electron guns for specific welding applications. These guns also use robust thermionic emission cathodes, which can be shaped to provide electron beams for custom applications. As examples, uniform electron beams can be focused, for delivery to the work pieces, in ring shape or as straight lines, in addition to spots. The ring shape permits the butt-welding of two ceramic cylinders, for example. The further development of such electron sources leads to possible applications in micromachining, also.

The Harwell coating techniques developed by Dugdale are being directed toward a number of applications. Corrosion-resistant coatings immediately suggest themselves; protective ceramic coatings or noble metal coatings might be used. Another very simple application, which carries with it a potentially large economic value, is the deposition of nickel onto aluminum, allowing for soldering to aluminum cable, as easily as to copper cable; Harwell is currently discussing this application with cable manufacturers. Still another possible application is the facing of tools with selected carbides or, more generally, the deposition of hard-wearing surfaces. (A. Sosin)

## CONFERENCE ON FIBER-REINFORCED MATERIALS

On 23 and 24 March 1977 the Institution of Civil Engineers in London sponsored a Conference on Fiber-Reinforced Materials. This meeting featured 22 speakers from universities, industry, and government laboratories (with only one exception, all within the UK). The audience consisted of 180 delegates, 45 of whom were from outside the UK. The absence of foreign contribution to the scheduled presentations was offset by the provision of ample discussion periods, during which many European delegates presented their work in illustrated talks. The emphasis in the Conference was on design and engineering applications of composite materials. Accordingly, many papers were entirely application oriented, and the analytical works were closely associated with practical design. Proceedings of the Conference can be obtained from The Institution of Civil Engineers, Great George Street, London SW1P 3AA.

In the opening session, H.L. Cox (National Physical Lab., retired), outlined the general principles that govern stress analysis of composites. He identified two systems of stresses

in these materials: the primary system, based upon average mechanical properties of the composite, and the secondary system, which defines the stresses between the individual components of the material. The primary system normally suffices for linear elastic analysis, but to understand creep, yielding, and failure of the material, the secondary stresses must be considered. Cox also discussed the concept of the equivalent isotropic structure (a distorted model that matches the stiffnesses of a given anisotropic structure), optimum fiber distribution for minimum weight, and laminated structures.

The optimum design of a composite ring reinforcement for a circular hole in a plate was discussed by E.H. Mansfield (Royal Aircraft Establishment, Farnborough). By combining an exact solution for axially symmetric deformation of a circumferentially reinforced ring with a plane-stress solution for the plate, a description of stresses throughout the structure was obtained. It is found that the effect of the hole can be eliminated by a ring that weighs only 70% as much as the plate removed (aluminum plate and carbon-fiber-reinforced composite assumed). Numerous design charts are included in the paper.

A.J.M. Spencer (University of Nottingham) presented a paper which pointed out that strong anisotropy can simplify stress analysis. Often a problem that requires numerical solution when the material is isotropic can be solved analytically when the material is highly anisotropic. The simplification arises from the fact that when the elastic moduli for various directions differ by large amounts, certain terms in the governing equations can be deleted. Closed-form solutions were presented for three problems: (1) a cylindrically wound, pressurized circular cylinder with flat end closures, (2) a junction of two plates, shown in Fig. 1(a), and (3) stresses in the neighborhood of the edge of a crack that propagates normal to the stiff direction of the material. Spencer's advice was to "think about the problem a little before reaching for the finite element program." (Only his and Mansfield's papers used analytical rather than numerical methods.)

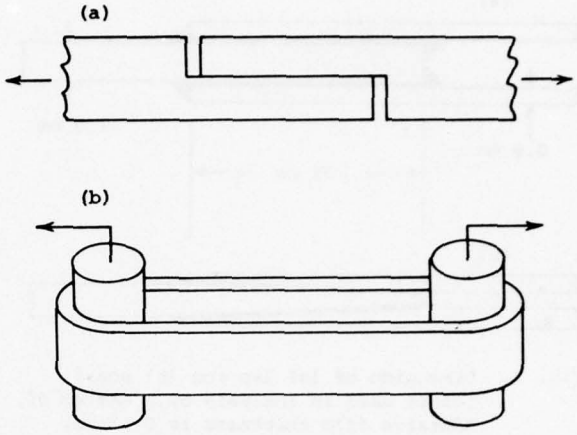



Fig. 1. (a) Junction analyzed by Spencer
(b) Strap link treated by Hedley *et al*

R.D. Adams *et al* (Univ. of Bristol) employed the finite element method to analyze stresses in bonded joints in composites. Three types of joints were studied, and the geometry of the adhesive layer (including fillets where the adhesive exudes from between sheets of composite) was realistically modeled. Maximum stresses were found to reside at the ends of the sheets in the fillet region of the adhesive. The most efficient joints were those in which the sheets were tapered so as to minimize discontinuities in thickness; stresses are reduced about 25% in going from a "lap" joint with sheets of uniform thickness to a "scarf" joint in which the sheets are tapered to 10% of original thickness over the length of the joint (see Fig. 2). Accurate analytical prediction of joint failure would require very detailed data on adhesive properties.

Another finite element analysis, of a strap link [a belt-like loop of composite material stretched between two parallel pins--Fig. 1(b)], was described by G. Hedley *et al* (British Gas Corporation). An iterative procedure was developed to determine, concurrently with the calculation of the stress field, the normal and frictional forces between the strap and pins. The method was then used to

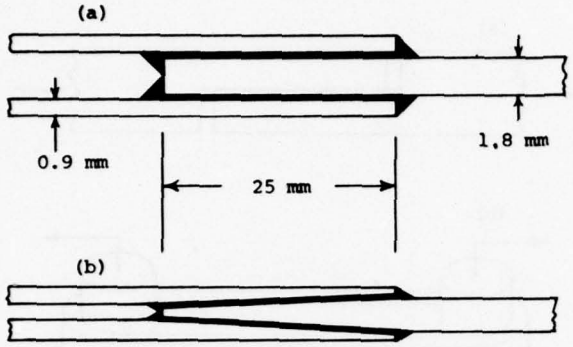



**Fig. 2. Dimension of (a) lap and (b) scarf joints used in analysis by Adams *et al*. Adhesive film thickness is 0.15 mm, with 45° and 60° fillets in cases (a) and (b), respectively.**

predict failure loads for strap links of carbon-fiber-reinforced epoxy with various ratios of strap thickness to pin diameter. The straps were filament-wound to maximize tensile strength. Predicted failure loads agreed well with experiment for the thicker straps but exceeded the measured values by almost 100% for the thinnest. This discrepancy was attributed to an influence of bearing stresses at the pin upon failure of the composite. Such effects were not present in the simple tensile tests from which the basic strength data had been determined. Fatigue tests were also run. It was found that the specimens, under a static load of 0.6 UTS (ultimate tensile strength) and a simultaneous alternating load of 0.1 UTS, failed after approximately $10^6$ cycles.

R. Tetlow (Cranfield Institute of Technology) presented design principles for multi-layer composites. Of interest to designers are his charts for three-layer, carbon-reinforced plastics, where stresses and stiffnesses are plotted in terms of the angular relationships between the fibers. The properties of a single layer were determined by experiment, then combined analytically to yield the properties of the three-layer material. Optimum design to resist buckling is also considered.

Several papers contained attempts to express quantitatively the post-yield behavior of fiber-reinforced materials, after cracking of the matrix and failure (or pull out) of the fibers have begun. The phenomena that take place are very complex; such factors as the changing angles of fibers spanning cracks and the changing embedded lengths of fibers slipping out of the matrix must be considered. While models can be devised and parameters adjusted to match selected sets of experimental data closely, the likelihood that analysis will play a major role in this area seems remote to the writer.

Perhaps the most fundamental experiments reported at the Conference were those by W.F. Thomas (University College, Cardiff), who determined the breaking strength of borosilicate E-glass fibers as a function of diameter and coating. The fibers were drawn from a melt, wound into bundles, and impregnated with either epoxide or polyester resin. Tensile tests of the bundles revealed strengths that varied from 0.8 $GN/m^2$ (epoxide) and 1.4 $GN/m^2$ (polyester) for 50-μm fibers to 3.2 $GN/m^2$ (both resins) for 5-μm fibers. The strength of uncoated fibers varied from 0.6 to 1.1 $GN/m^2$ for the same diameter range. According to Thomas, the strength of coated fibers approaches 3.6 $GN/m^2$ (522,000 psi), the strength of defect-free glass, as diameter approaches zero. (The low strength of uncoated fibers is attributed to abrasion between fibers under load.) The realization of strengths twice that of high-grade steel in a non-critical material that weighs less than one-fourth as much as steel underscores the potential of fiber reinforcement.

C.S. Smith *et al* (Naval Construction Research Establishment, Dunfermline) described the research and development program at NCRE in naval vessels constructed of glass-fiber-reinforced plastic (GRP). In 1972 a 47-m minehunter vessel, HMS WILTON, was launched. Now under construction is a 60-m mine-countermeasures vessel. No precedent existed for design of GRP ships of this size, and consequently much basic work was required in stress analysis, materials testing, and validation of final structural design.

The GRP used in the ships is a laminate of woven E-glass cloth in polyester. Net tensile strength is 0.24 $GN/m^2$, about that of mild steel. Difficulty was experienced in producing bonded joints that could withstand

underwater blast loads, and as a result bolted joints are used extensively. While the tensile strength is high, the modulus of the GRP is only 7% that of steel. Consequently, buckling of flat panels under compressive load was a problem, and much analytical and experimental work was conducted to arrive at suitable stringer-stiffened panel configurations. Finite element methods were used in the analysis, and most of the experimental work was conducted in reduced scale.

A number of papers were devoted to fiber-reinforced concrete (FRC) (see p. 200, this issue). In contrast to fiber-reinforced plastics, where fabrication techniques permit the use of long fibers with orientation set for maximum strength, all FRC at present must use short, randomly oriented fibers to facilitate mixing and casting. Fiber materials discussed in the papers included glass, asbestos, polypropylene, and steel. Several types of steel fiber were covered: round and square wire, corrugated fibers, and the new "melt-extraction" variety. The latter are produced directly from the molten steel by bringing rapidly spinning, knife-edged disks into contact with the melt. The steel wets the disk edge but is thrown from the disk after leaving the melt. Notches about the circumference of the disk induce fracture and control fiber length. This process is considered a breakthrough in reducing cost.

Typical tests of steel-fiber-reinforced beams show increases in ultimate strength and stiffness by as much as 50% and 100%, respectively, relative to similar unreinforced structures. Maximum fiber length currently employed is about two inches. Several speakers alluded to intensive efforts to develop techniques for using long fibers in concrete. This work is closely guarded because of the commercial potential.

The flexibility provided by fiber reinforcement is expanding the role of concrete as a structural material. J. Edginton (Johnson and Nephew, Ltd., Ambergate) described how fibrous concrete can be sprayed onto irregular surfaces to provide a high-strength layer with fibers largely parallel with the surface. J.A.H. Hartmann (Royal Military Academy, The Netherlands) discussed such varied applications of fibrous concrete as the construction of roads, chemical reaction vessels, and machine frames. As a replacement for cast iron in the last example, concrete features lower cost and higher internal damping. Surface finishes better than 10 μm have been achieved.
(William G. Soper)

## MECHANICS

### FLUID MECHANICS RESEARCH AT THE AERODYNAMISCHE VERSUCHSANSTALT, GOTTINGEN

The Aerodynamische Versuchsanstalt (AVA) in Göttingen is a major laboratory of the Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR). The DFVLR is the German equivalent of our NASA. The importance of the Fluid Mechanics program of the AVA is underscored by the fact that the Institute has three distinguished co-directors, namely, Prof. Dr. H. Ludwieg, Prof. Dr. Ing. K. Oswatitsch, and Dr. F.W. Riegels. This trio will soon be joined by a fourth co-director, Prof. Dr. H. Görtler. The reason for the concentration of this talent at Göttingen lies in the decision by the DFVLR to move two of its smaller fluids research institutes located in Aachen and in Freiburg i.B. to Göttingen.

The new director of the AVA Research Center is Prof. Dr. Jürgen Barche who succeeds the now emeritus Prof. Dr. H. Schlichting. Besides the Institute of Fluid Mechanics, the Center has an Institute for Rarefied Gas Dynamics directed by Prof. Dr. W. Wuest, and an Institute for Aeroelasticity directed by Dr. Ing. H.W. Förshing.

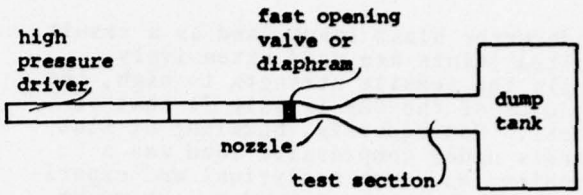
Like NASA, the DFVLR's program is mission- and application-oriented in good part, and it seems that it will become even more so in the future. A large part of the program at the AVA is, therefore, devoted to obtaining various types of performance data experimentally in one or another of the large wind tunnels.

The ongoing theoretical program at the Fluid Mechanics Institute consists of modeling compressible, subsonic turbulent boundary layers; the Boundary Layer Research Department of

the Institute is headed by Dr. Hans Ulrich Meier who collaborates with the emeritus though still active, Dr. Julius Christian Rotta in the numerical modeling of turbulent jets and wakes as well as boundary layers. The algorithm used is a closure scheme via the turbulent energy equation similar to a Launder-Spalding method. The modeling is also concerned with the three-dimensional boundary layer where the direction of the shearing stress is not necessarily in the plane of the velocity gradient.

Another theoretician, Dr. Paul-Armin Mackrodt, has investigated the stability of flow in pipes which are rotating about their axes. He has found that while the pipe flow is stable in the non-rotating case, it exhibits a linear instability (with respect to infinitesimal disturbances) for small rotations, and thus if a small eddy were to enter a pipe, it might destabilize the flow at a sufficiently large Reynolds number. However, he is now preparing to study the aerodynamics of high-speed trains up to Mach numbers of 0.4 along with associated problems of trains passing each other, and tunnel entrances.

The experimental facilities of the AVA are unique in many ways. There is a laboratory containing a number of Ludwieg tubes (named after their inventor Prof. Dr. H. Ludwieg, a co-director of the Institute) for the investigation of gas dynamic flows up to a Mach number of 12. A Ludwieg tube uses an expansion wave propagating into a high-pressure region to regulate and equalize the flow behind it. The high-pressure end sections of the Ludwieg tubes at the AVA are 80 m long. The high-pressure section is connected to a fast-acting gate valve (opening time approximately 0.02 sec) and empties through a convergent-divergent nozzle to a test section and finally a dump tank. The high-pressure storage tube may be heated to a variety of stagnation temperatures (up to 850°C) and be pumped up to 150 atm pressure. At the higher pressures and temperatures, a cooled pressure container surrounds the high-pressure tube and reduces the stresses on the heated tube. The facility consists of three separate tubes and is the only one of its kind. The maximum Reynolds number obtainable in the facility is $5 \times 10^7$ per meter and is at a Mach number of 5.




**Expansion wave in high pressure end serves to regulate delivery of driver gas to nozzle and test section**

**Schematic Arrangement of Ludwieg Tube**

The Ludwieg tube facility at AVA now is being used in the area of reentry lifting bodies and high-speed heat transfer. There is also a study in progress concerning the characteristics of a transonic test section with particular emphasis on the uniformity and non-turbulence of the flow; the work is part of a pilot study for a large transonic Ludwieg tube facility to reproduce actual flight Reynolds numbers.

There is a fine cascade tunnel facility at the AVA for the testing of compressor and turbine blading. The director, Dr. Ortivin Lawaczeck, explained that the tunnel is a sealed, closed loop with operating pressures of 0.1 to 1 atm. He said that transonic cascade design studies are a speciality of his department. The Mach number range of the tunnel is from 0.5 to 1.4, the test section is 380 mm x 125 mm and can accommodate 5 to 10 blades. A problem being studied in the tunnel is the effect of cooling air in the blade being blown out of the blade tangentially at the trailing edge. It seems that the cascade efficiency is increased by such injection of cooling air through keeping the boundary layer attached. Freon 12 has been used as a working fluid to simulate wet steam. The ratio of the specific heats of wet steam is distinctly below that of air or, for that matter, any gas with comparable degrees of freedom; as the state of wet steam is varied isentropically, its composition (wetness) changes. Freon simulates this ratio of specific heats and, being a more massive molecule than $H_2O$, has a lower velocity of sounds at the same temperature.

A new tunnel is being installed in the cascade tunnel facility to

accommodate a rotating, annular cascade. There are no guide vanes; the wheel rotates to provide the correct inflow angle. The tip and root (hub) diameters of the cascade are 0.586 and 0.456 m respectively.

A draw-down tunnel (circa 1956), the oldest tunnel at the AVA, was the first built in Germany after WWII. It has a vacuum storage chamber of 10,000 $m^3$ volume, a large dryer, turbulence damping screens, interchangeable subsonic and supersonic nozzles, and a test section 750 mm square. Airframes, missiles, 2-dimensional wings, and half models can be run for stretches of up to 2 min, but usually 30 sec suffices to cover an angle of attack range of 10°-15°.

There is a transonic tunnel (approximately 10 years old) with a 1-m square test section and a continuously adjustable nozzle to cover a Mach number range of 0.4-2.5. The test section has perforated walls, and a Reynolds number of 2 x $10^6$ per 10 cm is obtainable at 2 atm. The Airbus, Starfighter, 2-D wings, re-entry vehicles, missiles, and various stages of missile separating from an airplane have been and are being studied in this tunnel.

Under construction is a low-speed flutter tunnel to study building aeroelasticity, and wing-flap systems. The design Reynolds number goes up to $10^8$.

In addition to the foregoing, there are a number of other major tunnel facilities along with a computer center (IBM 370/158) for on-line data processing. (Martin Lessen)

## ABOUT DOLPHINS

Since drag reduction is a very serious matter to aeronautical engineers and naval architects, and active research in this subject on aquatic mammals is in progress at the Dolphinareum in Harderwijk (The Netherlands), it was with keen anticipation that I visited this installation to meet and exchange ideas with the Zoological Director, Dr. W.H. Dudok Van Heel. Van Heel carries on research on dolphins in collaboration with Dr. P.E. Purves (recently retired from the British Museum of Natural History) and Prof. R.J. Harrison of the Department of Anatomy, University of Cambridge and Dean of Downing College.

The dolphin is an extremely intelligent and fascinating animal--the voluminous material written about it contains some fact, more pseudofact and still more fancy. The dolphin is reputed to be capable of swimming at great speed with considerably less expenditure of energy than a mechanical self-propelled body of roughly the same size and shape using the best of present technology. During a transatlantic crossing, I observed dolphins riding the bow wave of the SS UNITED STATES doing approximately 35 knots; for the dolphin to have positioned himself on the bow wave, he would have had to be capable of swimming at a comparable speed. Van Heel noted that dolphins, during chase by speedboats, have exceeded speeds of 40 knots, while killer whales (*orcinus orca*) have been observed passing boats moving at speeds in excess of 26 knots.

In order to study the hydrodynamics of the dolphin, Van Heel, Purves, and A. Jonk of the Ship Model Test Station in Wageningen prepared a full-size wooden model of a Florida bottle-nosed dolphin (*Tursiops truncatus*) by replicating the actual contours of a live specimen. The model was tested in a towing tank at various angles of incidence, and it was found that at the speeds tested the drag exceeded that of an optimum body of revolution.

The towed model and a live dolphin in glide should both experience flow separation at the aft end. However, a dolphin probably keeps his boundary layer attached when he propels himself because the thrust of his tail on the water produces a pressure distribution about his afterbody that decreases slightly with distance downstream. The drag of a live dolphin in glide is somewhat less than that of the solid model. This difference in drag between the two can only be ascribed to differences in posture and attitude (both of which are fixed for the model), and to modification of the boundary layer of the live animal.

Van Heel noted that the blubber on a dolphin, which is about an inch thick, consists of two different kinds. One type simply stores fat while the second seems to serve some other function and is never metabolized away, even in a starving animal. I had the

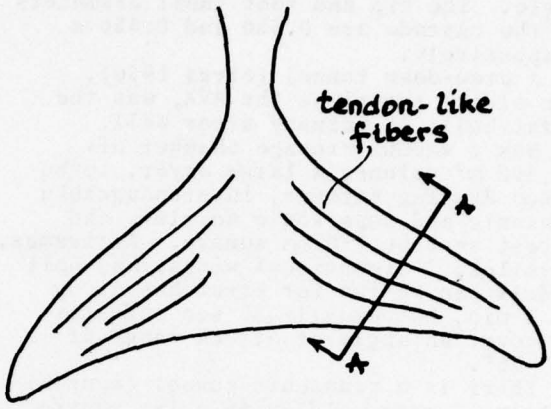
opportunity of feeling the consistency of the skin of both a live dolphin and a killer whale and can best describe it as resembling a thick layer of foam rubber covered by a thin membrane.

It has been shown recently that the epithelium in cetaceans does not contain a dead outer layer as in terrestrial animals and that, furthermore, recesses in the skin and openings to the exterior contain long-chain molecules (muco-polysaccharides) which are continuously secreted. It is therefore conjectured that some drag reduction occurs by boundary-layer conditioning through the addition of small amounts of muco-polysaccharides in the same way that polymer additives to water reduce the power requirements of fire-engine pumpers.

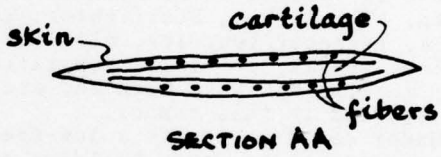
It had been conjectured by many that the dolphin reduces its boundary-layer drag by actively manipulating its skin in response to sensing turbulence in the boundary layer. It is now known, however, that there is no provision for either voluntary or autonomic control of the skin because the skin is devoid of the necessary muscles; therefore, whatever boundary-layer modification exists must be passive on the part of the animal.

A cetacean swims by moving its fluke (tail) up and down. At low forward speeds, the stroke is of large amplitude and low frequency while the opposite pertains at high speeds. The trailing edge of the fluke deflects under the pressure of the stroke and gives the fluke an angle of incidence with respect to the moving water that provides forward thrust. It was formerly believed that the power stroke in propulsion was a down stroke of the fluke and that the up stroke was merely a recovery stroke. However, the dorsal muscles (posterior to the spine and responsible for the upstroke) are about twice the size and weight of the ventral muscles (anterior to the spine and responsible for the downstroke), and so the former are capable of delivering a more powerful stroke than the latter.

The structure of the fluke also gives a clue as to which stroke is the more powerful. The fluke consists of a cartilaginous core, tendon-like fibers that run spanwise in a swept-back direction above and below the cartilage, and a covering of skin. It is significant that the fibers near the upper surface are straight (therefore, inextensible)




FLUKE of DOLPHIN




SECTION AA

whereas those on the lower surface are coiled (hence extensible). Therefore, during an upstroke, the fluke does not bend in a spanwise direction, whereas during downstroke, it does. The fluke's resistance to motion in a downward direction is therefore reduced relative to that associated with an upward stroke commensurate with the relative capabilities of the dorsal and ventral muscles. Van Heel also noted that the dorsal fin of the faster cetaceans is located further back on the animal than in the slower ones.

In a demonstration, a trainer had a dolphin leap after a short horizontal run (in which the animal accelerated) of less than 30 ft so that his centroid was about 16 ft above the surface of the water. Simple arithmetic shows that the animal must have been moving at about 18 knots vertically when he left the water. Van Heel asserted that the dolphins can leap much higher. If a collar is placed on a dolphin ahead of his pectoral

fins, the boundary layer is separated; with collars of cross-sectional diameter from 1/8 to 1 in. the dolphin would not achieve speeds greater than 8 knots.

While submerged, the blood circulation of a cetacean is principally to its brain. The metabolism in cetacean muscles is different than in terrestrial animals in that the oxygen-consuming restitution phase can be delayed for relatively long periods during which time its operation is anaerobic. The overall operation may therefore be less efficient than in an animal with normal metabolism, and therefore, the power available for propulsion may be even less than that estimated on the basis of normal metabolism.

Much remains to be learned about the dolphin. It is still a moot question whether or not the dolphin utilizes any mechanism at all to reduce his drag. If he does and if such a mechanism could be used to reduce the drag of water craft, the resulting higher speeds and smaller expenditure of energy could result in great savings for ocean transport. (Martin Lessen)

## OCEAN SCIENCE & TECHNOLOGY

### CONCRETE SHIPS--IS THERE A FUTURE?

Surprise! Surprise! Concrete ships and lighter-than-air dirigibles have a lot in common. At least that is the way it appears when looking at their past histories and prospects for the future. During the first half of this century, ships made of concrete plied the oceans in significant numbers while lighter-than-air (LTA) craft were plentiful in the sky above. For one reason or another, both lost out to their respective competitors and went the way of the dinosaur. Today, neither dirigibles nor concrete ships are operating, but both vehicle forms appear to benefit substantially from application of new technologies. And both have significant support from large numbers of enthusiastic and articulate advocates for reintroducing their respective vehicles into the commercial world. Alas, although the advocates for each system are many and seem to be growing in number, finding among them backers willing to put money into constructing a prototype vehicle has been unsuccessful. Studies and proposals abound, but no new dirigibles or concrete ships are under actual development. The future prospects for LTA were discussed in a one-day symposium at the Royal Aeronautical Society in London in late 1975 (see *ESN* 30-1:1).

The advocates for concrete ship construction met for a one-day symposium at the University of Delft in March 1977. The audience of more than 200, mostly Dutch but including several UK, US and German representatives, gathered to hear papers describing progress of current studies on technological improvements and commercial prospects for concrete ships. The Naval Architecture and the Civil Engineering Departments of the University of Delft cosponsored the well-organized symposium.

The proceedings opened with a paper by J.J.W. Nibbering (Univ. of Ghent) describing ship construction requirements including details of the types of forces a ship must be designed to withstand in various sea conditions including those mountainous seas a ship is expected to meet once every fifty years. The second paper presented by J.J.B.J.J. Bouvy (Consultant, Den Haag), answered the challenge of the first presentation by describing concrete and its properties under various loads according to the method of reinforcement and prestressing. He concluded that current reinforcement and prestressing techniques could meet the challenge of the sea and allow construction of much lighter-weight concrete ships than those built in WWII and earlier.

A history of concrete ships since 1887 was then presented by J. Buijs (D3BM Construction Co., Rotterdam). He pointed out the rugged survival capabilities of previous concrete ships that have run aground. Based on extrapolation of this past history, he predicted that concrete ship hulls built using modern construction methods would be 20 to 50% heavier than steel ships but would require less than 50% of the hull maintenance effort and would last at least twice as long. In fact, the greater than 50-year technical life for a concrete ship could represent a problem. What does

one do with an indestructible ship after its competitive commercial life is over and there is no scrap value in the hull? Environmentalists might object to any plans to sink them at sea, and the need for floating restaurants and harbor breakwaters is not insatiable.

Yacht builders were treated to an excellent paper by S.P. Shah (Univ. of Illinois) describing methods and merits of ferrocement construction of smaller ships. He defined ferrocement as a combination of wire mesh and cement. The key design factor in using ferrocement is the surface area of reinforcement wire for a given volume of matrix: the greater the strength desired, the greater the wire surface area required. He described his own research on impact testing of ferrocement in which he measures the extent of damage by the rate of water leakage through cracks in the matrix resulting from the impacts. He is attempting to join in a cooperative test program with the Universities of Sheffield, Munich, and Delft and The Netherlands Royal Military Academy for the purpose of testing strengths of ferrocement construction. Data in this area are evidently sparse.

Enthusiasts for concrete ship construction came alive when K. Finsterwalder (Wyckerhoff and Widmann A.G., Munich) showed drawings and specifications of a proposed large concrete liquid natural gas (LNG) tanker his company is trying to market. The ship (288 m long) is to carry 125,000 $m^3$ of liquid natural gas. As concrete has much better cryogenic properties than steel, a large LNG tanker represents one of the more promising opportunities to bring concrete ship construction back to life. Ironically, large dirigibles carrying natural gas also seem to be one of the more promising possibilities for LTA in the future.

After having presenters preach to the choir most of the day, the last two took some of the enthusiasm out of the gathering. B. Rapo (Lloyds Register of Shipping, London) outlined underwriting and insurance prospects for the builders of any new concrete ships. The requirements of the underwriters were realistically spelled out and, although not bleak, they did not support enthusiasm for an early return of these vessels. "Return on Investment" was the title of the last paper by J. Smit (Rijn-Schelde-Verolme, Rotterdam). His thesis was that actual construction costs of concrete ships will have to be on the order of half that of steel ship construction before any company will gamble on this new technology. The principal operational savings are expected from cheaper hull maintenance of concrete ships; however, for a given capacity, the concrete ship will have about a 50% greater deadweight than a steel ship, and this will require greater power plant costs which approximately equal the gains from hull maintenance. However, he did breathe some hope into the audience when he presented forecasts for escalating costs of steel shipbuilding in spite of the extreme competition in the industry caused by the current glut of worldwide shipping. The forecast for steel versus concrete costs shows a widening of the gap in favor of concrete. Smit concluded that this growing advantage for concrete may lead to construction of a few concrete ships for carrying especially corrosive cargoes that attack the holds on steel ships.

In summary, just as in the case for LTA, technological improvements are beginning to make concrete ships attractive again. We may yet see the revival of concrete ships at sea and dirigibles in the air above them. (CAPT. L. Roy Patterson)

## ENVIRONMENTAL LOADING OF OFFSHORE STRUCTURES

The exploitation of North Sea hydrocarbon deposits has resulted in the installation of a large and growing number of platforms, now in the hundreds, in that difficult environment. While, as C.J. Antonakis of the Hallcrow Ewbank Petroleum and Offshore Engineering Co. noted when he chaired a discussion meeting on environmental loading of offshore structures recently, these structures are not all falling down, there is a well-recognized need for greater knowledge of environmental loading factors. This interest, in fact, represents one of the principal current thrusts of the UK's research efforts in support of its offshore activities.

At the discussion meeting organized by the Society of Underwater Technology on 31 March 77, the principal speaker was Dr. H.H. Pearcey, Head of Research at the National Maritime Institute, Feltham, who undertook a review of progress being made in research into environmental loading. About sixty attended the meeting with representation from industry involved directly or indirectly in offshore activity, government and the universities including Salford, Liverpool, Glasgow, Southampton, Cambridge and London (University College).

Pearcey first outlined the importance of the respective roles being played by fundamental theory, hydrodynamic and aerodynamic laboratory model studies and work at sea, both at intermediate and full scale. He stressed the importance of fundamental theory as a guide in the seeking of both model and field data and to the assurance of its correct use. Intermediate- and full-scale work are essential for confirmation of theory and model work. He proceeded to acknowledge the contributions being made by the large number of activities interested and working in the various facets of research related to the environmental loading problem. They include the Departments of Energy, of Industry, and of the Environment; the National Engineering Laboratory; the Hydraulics Research Station; the Building Research Station (BRS); the National Maritime Institute (NMI); the British Hydrodynamics Research Association (BHRA); Shell; British Petroleum; the Science Research Council; and the universities, a number of whom contributed to the subsequent discussion.

Identifying the principal elements determining wave-loading as drag and inertial terms, Pearcey noted that the latter are well covered theoretically, with good agreement between theory and experiment. Here the theoretical understanding is such as to allow for shapes to be handled analytically, computationally and in laboratory models. There is reason for confidence in going to full scale, although one awaits confirmation at intermediate- and full-scale at-sea measurement. In general one is ready to assist in the design of the next generation structures and to arrive at their general features, such as anchored platforms with both taut and splayed cable systems. Pearcey demonstrated the value of small-scale model work in a film showing the behavior of cable-tethered platform models of a variety of configurations and under various loading conditions in wave tank tests. Effects exhibited in the film included (i) cable twitching, emphasizing the need to design the system to keep cables taut under all the possible wave forces and to consider the effect of the load on the platform in this regard, (ii) development of instabilities as the wave frequency increases and (iii) buoyancy chamber design.

Pearcey then proceeded to discuss the drag term and the difficulties of extrapolation through the critical region to the post-critical situation, noting that most laboratory experiments had been in the subcritical region.

Initiating further discussion with a plot of the coefficient of drag as a function of Reynolds number, prepared many years ago, and an excellent example of a shotgun distribution of points, Pearcey proceeded to identify factors of concern in connection with the uncertainty in the drag term, namely, scatter in the coefficients of drag and moment, $C_D$ and $C_M$; random variations in particle kinematics; Keulagen-Carpenter number; Reynolds number; vortex shedding; currents; orientation of the member; dynamic interaction; proximity of other members; roughness and marine growth; and wave slamming. He singled out vortex shedding as a central theme for discussion and review, covering a range of topics including uniform and oscillating flow, splitter plates, twin cylinders, and differences between vertical and horizontal orientation in the wave field.

Pearcey then proceeded to emphasize the importance of the NMI Christchurch Bay test rig, the general features of which have been described briefly in an earlier account, *ESN* 31-3:125, March '77. Many of the special instrumentation developments incorporated in the rig were also covered previously in a note by J.P. Walsh, "Strain Measurements Offshore", *ESN* 29-11:480, Nov. '75. This test facility takes research into the real sea at a scale large enough to produce loads that can be extrapolated to full scale with confidence. The scale remains small enough, however, in relation to the statistical wave climate for the full range of pertinent wave loads to be

experienced within a reasonable time. Careful choice of the rig's dimensions and environment are believed to have provided a true intermediate scale model. The dimensions of its vertical test cylinders, one large in diameter and the other small, are such as to assure one being in the drag and the other the inertial regime. Exceptionally heavy seas in Oct. 1976 resulted in some damage to the platform, which was accompanied by some settling into the bottom. A film taken from the air of this rig at the time graphically confirmed the realism of the model and its scale, but suggested that the wave statistics on which it was based were perhaps a little out. Preliminary particle velocity and force data obtained at various depths on the two cylinders were shown as examples. They exhibited expected differences in the spatial patterns in the drag and inertial regimes confirming the functioning of the instrumentation and the value of the experimental data which is and will be obtained. Pearcey concluded by reemphasizing the importance of this intermediate-scale field work in developing statistical data for the use of designers.

In subsequent discussion A. Gallagher (BRS) briefly outlined the nature of the instrumentation installed by BRS in the Christchurch rig for study of the behavior of the sea bed under load. This includes an array of pressure cells both in the heavy concrete base and in the sea bottom beneath. Preliminary results indicate that observed pressure changes are dominated by the wave forces, although there are components due to overturning forces. Additional components observed in the sea bed arise from vibration of the tower. They could be excited by the vortex shedding frequencies or possibly by surface-wave harmonics being near a structural resonance.

Robin Webb (BP) then briefly reviewed two full-scale wave and stress investigations in the North Sea. The first had been on platform C in the West Sole Field and had been conducted in the early '70s over an 18-month period. A maximum wave height of 38 ft had been observed. Results show that (i) a linear relationship exists between stress and water surface elevation, (ii) normalized stress against cumulative probability followed the Pierson Holmes Density function, and (iii) for wave heights of less than 6 ft, the variation of stress through the tidal cycle shows the greatest stresses at intermediate water (the gauges were near mean sea level). Slam effects were primarily observed in the vertical plane. The second investigation was initiated only recently on a platform in the Forties Field. There is provision for measurement of wave force, water particle motion, strain wave height, and wave slam. Results will be publicly available in 4 years!

Other discussants included (i) M.J. Tucker (IOS) who discussed $C_M$ and $C_D$ as functions of the Keulegan-Carpenter number and concluded by emphasizing the importance of the maximum value of $C_D$ as determining the breaking of a structure; (ii) M.M. Zdravokovich (Univ. of Salford) on some aspects of vortex pairing, and who noted that the use of elliptical rather than circular sections should produce much less scatter in drag data; and (iii) D.J. Maull (Cambridge Univ. Engineering Lab.) who commented on nonrepeatability in drag data and noted that in model tests of a circular cylinder over a period of time the maximum values of lift forces reached due to vortex shedding were consistent although the duration periods and time of separation of the various bursts differed.

Concluding the meeting the Society's President Sir James Lighthill, FRS, complimented Pearcey on his successful and constructive application of his earlier experience in transonic flow to the underwater case, and on his success in providing an excellent review of a complex field, characterized by backward and forward motion.

There can be little doubt that the new facilities available for work in this field which now appear proven will make a substantial contribution to progress. Pearcey's review and the ensuing discussion are expected to be published in the June issue of the *Journal* of the Society. (A.W. Pryce and M. Lessen)

**ONRL REPORTS**

See the back of this issue for abstracts of current reports.

# PHYSICAL SCIENCES

## NEW GAS LASERS--THE SEARCH CONTINUES

Since 1960 when A. Javan, W. Bennett, Jr., and D. Herriott [*Phy. Rev. Letters* 6, 106 (1961)] achieved laser action at a wavelength of 1.15 μm by an electrical discharge in a mixture of He and Ne gases, the search for other gas lasers operating at new wavelengths, higher power and energy, short pulsewidths and higher efficiency has been in progress. The "Search for New Gas Lasers" was the title of a one-day meeting of the Quantum Electronics Group of the Institute of Physics held at the Science Research Council's (SRC) Rutherford Laboratory near Didcot, Oxfordshire, on 25 February. The Conference was attended by about 90 people, all except two being from the UK. Eleven papers presented were from UK institutions. Three were invited reviews of gas laser research, while the remainder were reports of specific research. Frequent reference was made to work in the US where the level of activity is higher. As one might expect from a one-day meeting, not all aspects of gas laser work were covered. The emphasis of this Conference was on finding new gas lasers for the following purposes: A "Brand-X" laser for fusion work, isotope separation, plasma diagnostics, and waveguide oscillators. Most of the presentations described research covered in past meetings; however, some relatively recent results were given which I will discuss first.

Dr. M.W. McGeoch (Culham Laboratory and Univ. of Southampton) described his achievement of optical gain at ∿4700 Å in flashlamp-pumped Cd-Hg vapor. This work was reported at the IXth International Conference on Quantum Electronics in Amsterdam on 14-18 June 1976 and was the subject of a previous *ESN* article (*ESN* 30-9:420). It could also perhaps serve as a high-power blue-green laser for underwater use. McGeoch produced mercury and cadmium vapor in an oven-heated cell. Gain was determined by measuring the transmittance of the cell using an argon laser as the source. A gain of about 2% was measured on 5 argon lines in the range 4600 to 5200 Å. The gain decreases with increasing temperature, with the highest value around room temperature. The cell is pumped with a 100-J, 2-μsec pulse-duration xenon flashlamp. Gain is not observed until 10 μsec after the flashlamp pulse. McGeoch could not give a precise explanation for this peculiar behavior, but speculated that at lower temperatures metal vapors condense on the cell wall and then evaporate as a result of heating from the flashlamp, producing vapors in proper concentrations near the center of the cell for inversion to take place. This particular system has been examined recently by several people for possible fusion work.

Another new result was reported by Dr. A.J. Kearsley *et al* (Clarendon Laboratory, Univ. of Oxford). They achieved laser action for the first time in a fast-discharge laser containing Kr, $N_2F_4$, and $SF_6$ with optimum energy outputs of 750 and 160 mJ/liter respectively.

Dr. A.F. Gibson *et al* (Univ. of Essex) reported a technique which they say may be of value for stabilizing discharge lasers without the use of pre-ionization. They have used an electrode structure consisting of a 50-ohm-cm germanium cathode and a brass anode in an HF($SF_6$ + $C_3H_8$) waveguide laser. They get 4 to 5 J/liter energy in multiline output (which is about the same as the group at the Lawrence Livermore Laboratory is getting with twice the applied voltage). They also described their work with a TEA (transverse excited atmospheric-pressure) $CO_2$ waveguide laser using a 100-ohm-cm silicon cathode (1.5 mm x 1.5 mm x 30 cm) in a curved mirror cavity 44 cm long and having mirrors with identical radii of curvature equal to 14 cm. This laser produced 3-mJ output energy, a peak power of 10 kW and an average power of 0.4 W at a repetition rate of 1 kHz. The pressure in the cell was 2 atm. The authors claim that this is the first waveguide laser to operate at a pressure beyond 1 atm. In addition, the authors claim to get one-fourth the average power as P. Smith of Bell Telephone Laboratories does but with only 1/20th the pulse rate.

Dr. R.J. Dewhurst *et al* (Univ. of Hull) described their work on achieving population inversion on a carbon-VI transition at 182 Å. The authors use a technique whereby a carbon plasma is formed from a laser-heated carbon filament. As the plasma cools,

recombination takes place leading to a population inversion of the hydrogen-like n = 3 to n = 2 levels. They believe they have achieved population inversion based on comparisons of experimental spectral intensities of emitted radiation with those predicted by a computer model. The plasma-forming pulse from a Nd-glass laser is 200 psec long and has 100-200 mJ of energy. The authors calculate that a 10- to 100-J pulse would be required to produce laser action.

Dr. C.W. Webb (Clarendon Laboratory, Univ. of Oxford) presented an invited 30-minute review. The main emphasis of his talk was the search for a "Brand-X" laser for fusion work. A list of desirable parameters for such a laser would be:

wavelength - - - 0.3 - 10 μm
pulse energy - - $10^5$ - $10^6$ J
energy storage - 0.1 - 1 kJ/liter
efficiency - - - 10%
beam quality - - diffraction limited
pulse duration - $10^2$ - $10^3$ psec

The lasers currently being considered, all of which fall short in one or more of these requirements, are pure noble-gas excimer and noble-gas-halide excimer (or exciplex) systems. An excimer is a short-lived molecule which has a repulsive ground state and bound excited electronic states. Transitions can take place from the bound states to the lower lying unbound levels after which the molecule dissociates. Examples of systems which have "lased" include $Xe_2$, $Ar_2$, and $Kr_2$.

The term exciplex is sometimes used to describe a similar situation in heteronuclear molecules such as XeF, XeCl, XeBr, KrF, KrCl and ArF. Only one speaker used the term exciplex (Dr. M.H.R. Hutchinson); others used the word excimer to describe both homonuclear and heteronuclear systems. Pumping for these laser systems may be by ordinary electrical or electron-beam stabilized discharges or by electron-beam excitation.

Webb discussed operational schemes and limiting factors in excimer lasers. He also mentioned an oxygen laser system which operates at a wavelength of 5575 Å, a bandwidth of 4 Å and 5 J/liter of energy storage. He mentioned the possibility of a laser based on free atom transitions occuring after photolysis of $N_2O$.

Another invited paper was presented by Dr. M.H.R. Hutchinson (Imperial College). He gave a very good review of excimer lasers, in which parameters, wavelengths, optimum mode of discharge, and detailed reactions for loss and gain mechanisms were discussed. Hutchinson also talked about successful efforts at Imperial College toward achieving extreme uv lasers by multiphoton resonance pumping in gases. Laser action at 570 Å in Ar has been achieved by two-photon resonantly enhanced tripling of 1709 Å from a tunable Xe excimer laser. Hutchinson had reported this result last June at the Amsterdam Quantum Electronics Conference. He also mentioned the possibility of using a 5th harmonic in He. The record for shortwave laser action in gases is currently held by the US Naval Research Laboratory where 20th and 28th harmonics of 1.06 μm have been produced in gases.

The only report which prompted argumentative comments was a lively invited paper by Dr. M.J. Shaw (University College of Wales) on potential new excimer lasers in metal vapors. He first disagreed with Hutchinson on the definition of exciplex. Shaw prefers to use the name excimer for all the molecular systems which have a dissociated ground state. He discussed the search for new metal excimer lasers from basic considerations. It would be logical, according to Shaw, to look for atomic species which have a $^1S$ ground state so they can't share electrons when brought together. The rare gases of course fit, but what about metal vapors? Group IIA elements such as Ca, Mg, and Ba and Group IIB elements such as Hg, Cd, and Zn, as well as certain transition metals such as Pd, might be potential candidates. Shaw considered various parameters such as ionization energy, boiling point and dissociation energy for diatomic molecules, hydrides, and chlorides. He eliminated Pd because of its high boiling point, settled on the IIB group as being best and picked Hg as best of that group.

Shaw made splendid use of Rayleigh's old but good data of spectra in Hg discharges, particularly the 4850 Å bands. He considered Rayleigh's results showing how these two bands relate to each other and recent results by National Bureau of Standards (NBS) scientists and other workers showing that the

intensity ratio I(4850 Å)/I(3350 Å) is proportional to the concentration squared at low pressure but varies as the first power of concentration at higher pressures. This implies a three-body reaction which saturates at higher pressure. Shaw stated that a trimer $Hg_3^*$ is probably formed, from which the 4850 Å band is emitted. This agrees with a hypothesis by Stock of NBS.

Early attempts to get laser action from Hg bands have failed. Shaw believes that recent reports of 15% gain on the 3350-Å band by the USAF Weapons Laboratory may be in error. Other participants also voiced this opinion. Shaw feels that people should keep trying, however, and suggests other candidates: HgXe, HgH, HgTl and $HgNH_3$.

Dr. H.J. Baker and Dr. T.A. King (Univ. of Manchester) discussed the iodine laser system which they consider ideal as a short-pulse high-power gas laser. According to the authors, the stimulated emission cross section is $\sim 0.5 \times 10^{-19}$ cm$^2$ which is nearly optimum as this allows most of the stored energy to be extracted in subnanosecond pulses without parasitic oscillations robbing the system of energy. At the same time the saturation energy flux 0.5 - 1 J/cm$^2$ is less than the damage threshold of optical materials. Baker and King feel that if pump sources can be developed to a 3% efficiency level, an overall efficiency of 1% may ultimately be reached in the iodine system. It would then be a possible candidate for fusion work. A recent *ESN* article (*ESN* 29-6:280) describes the development of a high-power iodine laser in Germany.

Dr. C. G. Thomas (Univ. of Southampton) described a nitrogen laser with an interesting unstable resonator which produces a diffraction limited beam in a short discharge channel. The unstable resonator consists of a concave mirror with a radius of curvature of 467 mm and a convex output mirror with a radius of 4 mm and diameter of 1 mm separated by about 24 cm. The discharge channel size is 160 x 13 mm. The authors claim the alignment of such a cavity is a simple task.

The output pulse width is about 4 nsec (at half height) and the beam is rectangular in shape with 200-J output energy, one half of which is within the diffraction limited solid angle, 80 µrad x 18 µrad. On occasion they observe two exit beams, each diffraction limited and separated by 200 µrad. The explanation for this peculiar behavior is unknown. The authors stated that this same system should be suitable for other short-pulse laser gases as well.

D.J.M. Green *et al* (Culham Laboratory) presented an idea for optically pumping a molecular system to produce an infrared source suitable for isotope separation. For this purpose it is desirable to produce laser operation at high pressure and on many lines so that nearly continuous tuning is available. The authors have experimentally investigated carbonyl sulphide (OCS) pumped by a $CO_2$ laser operating at 9.57 µm. They produced laser action on several lines between 18.5 µm and 19.5 µm using an off-axis pumping technique. Computer modeling of laser parameters was carried out, and results compared well with experimental results. The authors believe that the potential of this type of laser is good and that it or similar systems can be scaled to higher powers and greater tunability.

Far infrared lasers pumped by optical means for plasma diagnostic experiments were discussed by Dr. D.E. Evans *et al* (Culham Laboratory). A list of desired laser parameters for this application was given by the authors as follows:

| | |
|---|---|
| wavelength - - - - - - - | 100-500 µm |
| power- - - - - - - - - - | 1 MW |
| bandwith - - - - - - - - | 50-60 MHz |

They considered two systems: heavy water ($D_2O$) and methyl fluoride ($CH_3F$), both pumped by a 10-J pulsed $CO_2$ laser. They obtained laser action in $CH_3F$ at 496 µm and on three lines in $D_2O$ at 385 µm, 114 µm and 66 µm. Peak powers range from 1 to 4 MW and average powers from 0.25 to 4.8 W. An interesting feature of this work is the use of an injection laser preceding the pump resulting in reduced bandwidth--55 MHz vs 300 MHz and increased power--250 kW vs 160 kW without injection in $CH_3F$.

The papers presented at this Conference show that several institutions in the UK are pursuing new gas laser sources needed for several important applications, such as fusion, plasma diagnostics, isotope separation, and short wavelength sources. Significant

results are being achieved in spite of the fact that funding is considerably less than that available in the US. (V. Smiley)

## UK SOLID STATE CONFERENCE '77

The 14th Annual UK Solid State Physics Conference, 5-7 January 1977, consisted of 11 plenary talks with invited speakers, a vitreous-state symposium of 6 sessions with 7 invited and 15 contributed talks, and 14 sessions on various subjects, each with 4 contributed talks; 3 or 4 parallel sessions were held.

The number of participants was almost subcritically low at 170. During the last four years an attendance of close to 300 had been maintained, compared to a maximum in earlier years of about 500. The low attendance seems to have been due partly to the high registration fees, partly to a serious restriction in travel funds (which has affected both universities and British Government laboratories, with the noticeable exception of the Univ. of Cambridge, which furnished about 30 participants), and partly to the location in Manchester, which seems to be least attractive in January. The Conference finds traditionally low attendance from industry, but attendance from abroad was also surprisingly low this year. Next year, the Conference will be moved to Warwick, but otherwise no major changes are planned, and a wait-and-see attitude will be accepted for another year.

Invited Plenary Talks--Extended x-ray absorption fine structure (EXAFS) was the subject of a presentation by J.B. Pendry (Science Research Council, Daresbury, UK). An x-ray photon is absorbed by an atom, an inner core electron is emitted, and the extended fine structure is due to the diffraction of the emitted electron from the other atoms in the solid. For systems with more than one species of atoms this method gives more information than conventional x-ray diffraction. The method has been tested on Cu, and the application to $As_2Te_3$ in glassy and in crystalline (metallic) phases is in progress.

J.W. Steeds (H.H. Wills Physics Laboratory, Bristol, UK) emphasized the tremendous advances which the electron microscope has made since its first model 40 years ago. Today, manufacturers can guarantee 3-4 Å resolution and the push is towards 1 Å. Probe size may be down to 10 Å for electron microscopy; chemical and Auger spectroscopy may be performed from 100-Å areas. The University of Toulouse has a 3-MeV electron microscope which is several stories high. The main problem of high-energy microscopes nowadays is radiation damage.

Application of scanning electron microscopy (SEM) and transmission electron microscopy (TEM) to an investigation of the growth of GaP whiskers from the vapor phase was discussed, and *in situ* observations were shown in two films by A. Maas (Univ. of Bonn, Germany). It could be seen that whisker growth actually proceeds by a vapor-liquid-solid mechanism via a droplet, at the tip of the whisker, with a diameter of about 250 Å. Depending on the thermodynamical conditions, this droplet may be liquid or crystalline. These studies should be important for a better understanding of liquid-phase epitaxy.

In an excellent talk, J.E. Midwinter (Post Office Research Centre, Martlesham Heath, UK) discussed problems in connection with optical fibers for use in the British Telecommunication Network in the 1980s. Some of these problems are non-ideal profiles of the refractive index across the fiber, an irreversible change of the index of refraction with temperature above 300°C, microcracks, and attenuation. The last is due to absorption and Rayleigh scattering. Absorption is caused by transition metal impurities in the glass (Fe, Cu, etc.) and depends on the oxidation state of these impurities, which is in turn related to the OH content introduced by the silica tubes from which the fibers are drawn. Rayleigh scattering is caused by density fluctuations and, for multicomponent glasses, by composition fluctuations. Paradoxically, one can make multicomponent glasses that exhibit less scattering than silica, but currently one cannot make fibers from these glasses.

In another excellent presentation, M. Archer (Univ. of Cambridge, UK) compared direct conversion of solar

energy by photobiological, photoelectrochemical, photovoltaic, and photochemical processes. Photoelectrochemical processes, which can give both electrical and chemical free energy and which are based on a modeling of certain photobiological processes (e.g., using artificial membranes) are particularly interesting. The efficiencies of these processes are still very low.

H. Ziljstra (Philips, Eindhoven, The Netherlands) reviewed the physics of permanent magnets. A plot of the logarithm of the maximum values of the BH product that have been achieved versus time during the last 100 years shows a linear increase, starting with BH = 2 kJ/cm$^3$ in 1880 (C-steel), and standing now at 200 kJ/cm$^3$ with the introduction of (Sm,Pr)$Co_5$ by Bell Laboratories. Extrapolation predicts a value of 1000 for the year 2000. Unfortunately, the material used by Bell and $SmCo_5$, used by Philips are very expensive.

V. Heine (Cavendish Laboratory, Cambridge, UK) emphasized that the local density of states (or modes) is a more appropriate quantity than eigenfunctions for describing amorphous materials, random alloys, defects in solids, and solid surfaces. Particles can feel only a certain range of their vicinity, on the order of a few wavelengths. Similar to the black-body radiation theorem, the local density of states in the bulk may be expected to be independent of the surface. Based on the tight-binding approximation, theoretical methods have been developed and computer programs established for convenient calculation of the density of states and related functions.

The nonlinear optical susceptibility of solids and applications for the generation of tunable coherent generation was discussed by D.S. Chemla (Centre National d'Etudes des Télécommmunications, Bagneux, France). $LiNbO_3$ is the most useful material because of the large crystals (up to 12 cm long) that are available. Of the semiconducting materials, $AgGaSe_2$ can be tuned from 0.3 to 14 μm, part of it continuously. Particularly promising are the organic crystals with highly nonlinear π-electrons; their nonlinearity can be 20 times higher than that of $LiNbO_3$ and a conversion of 30% can be achieved in 1-mm crystals.

A beautiful presentation on the role of solitons in nonlinear physics was given by R. Bullough (Univ. of Manchester Inst. of Science and Technology, UK). Various nonlinear wave equations have solitary waves as solutions, which do not change their profile with time, may collide and pass through each other, and conserve energy, momentum and various other parameters. Such solutions are called solitons. They behave like quasi-particles and can be treated as such for statistical mechanics. Examples of such equations and their application in physics are the Korteweg-de Vries (shallow water waves, tsunamis, ion acoustic waves, anharmonic lattice), sine-Gordon (self-induced transparency, fluxons in Josephson junctions, spin waves in the A and B phases of liquid $^3$He, Bloch walls), and nonlinear Schrödinger equations (self-modulation and self-focusing in nonlinear optics, deep water waves). Other fields of applications are one-dimensional conductors, elementary particle physics, and astrophysics. A soliton was first observed as a solitary wave in shallow water in 1834, although the term was not coined until 1965 for a solution of the Korteweg-de Vries equation. Solitons now have a width of applications in nonlinear physics which reminds one of the classical treatises on linear partial differential equations in mathematical physics.

P.J. Hendra (Univ. Southampton, UK) gave a chemist's approach to surface analysis. Infrared spectroscopy is an established technique for the identification of molecules on real surfaces as used for catalysis, thin coatings in air, etc. A relatively new and more difficult method is Raman scattering which, however, has the great advantage that it will also work under water for the investigation of electrode-electrolyte interfaces. Raman scattering has low sensitivity, and any occurring fluorescence is very disturbing. To eliminate the primary laser light, typical applications require triple monochromators. By using appropriately colored samples, resonance-enhanced Raman scattering can increase the sensitivity by a factor of $10^5$. Raman scattering can be used now to analyze 1/50 of a monolayer.

Reactive collisions of incident gas-phase atoms and molecules with solid surfaces and application to molecular beam epitaxy (MBE) of GaAs was discussed

by B.A. Joyce (Mullard, Redhill, UK). The investigation is considerably facilitated by modulating the atomic or molecular beam with a modulation frequency of at least 2 Hz. Depending on the temperature, arsenic occurs as $As_2$ or $As_4$ while incident, migrating or desorbed; only for the process of chemisorption (combination with Ga) does it occur in atomic form. MBE of GaAs may be useful for microwave and optoelectronic devices. It works for $Ga_{1-x}In_xAs_{1-y}P_y$, but is undesirable for $Ga_{1-x}Al_xAs$. The characteristic features of liquid phase epitaxy (LPE), vapor phase epitaxy (VPE) and MBE are compared in the table.

Contributed Talks--Because of parallel sessions, only a fraction of the presentations could be attended. A few samples will be given.

M. Bennett (Cavendish Laboratories, Cambridge, UK) emphasized that the locally strongly varying electron distribution in Si makes impermissible the use of a local empirical pseudopotential and leads to effective masses which are 10-15% off observed values. Calculation of screening with a model dynamic dielectric function allows introduction of non-local correction terms. The screened exchange interaction term, which enters additively in the effective band gap energy

| Process Characterization | LPE | VPE | MBE |
|---|---|---|---|
| *in situ* substrate cleaning | melt-back | back-etching | ion bombardment or thermally; monitoring by AES |
| growth rate (μm/min) | 0.1-1 | 0.05-0.3 | 0.001-0.03 |
| thickness (Å) control | ±500 | ±250 | ±5 |
| substrate temperature (°C) | 1120 | 1020 | 850 |
| interface topography | not smooth | smooth | very smooth |
| $N_D + N_A$ (undoped) ($cm^{-3}$) | $10^{13}$ | $10^{14}$ | $10^{16}$ |
| N trap ($cm^{-3}$) | $10^{12}$ | $10^{13}$ | $10^{4}$-$10^{14}$ |
| range of dopants | wide | wide | n: Si, Sn<br>p: Be, Mn, Mg |
| dopant concentration ($cm^{-3}$) | $10^{14}$-$10^{19}$ | $5x10^{14}$-$10^{19}$ | $5x10^{16}$-$10^{19}$ |
| doping profile | flat | sharp (300 Å) | very sharp (50 Å) |
| automation | difficult | possible | yes |

and which previously was considered to be continuous, seems to have a discontinuity at the Fermi energy.

M.J. Kelly (Cavendish Laboratory, Cambridge, UK) reported on his work with L.M. Falicov (Univ. of California, Berkeley) on many-valley many-body calculations of the n-type inversion layer electrons at the $Si(111)/SiO_2$ interface in the metal oxide semiconductors (MOS) structures. Self-consistent Hartree theory leads to 6 degenerate valleys, while experiment shows 2-fold degeneracy and a higher cyclotron effective mass than anticipated. Many-body theory can explain the experimental findings as caused by a charge-density wave ground state and spatial break-up in domains.

P.J. Dean (Royal Signal and Radar Establishment, Malvern, UK) reported on the investigation of the optical cross section of deep traps (Cr, O, etc.) in GaAs and InP by a double-source differential photocapacitance technique. The primary light source emits photons of 1.3 eV, while the probe light is scanned in frequency. The response indicates that the dominant transitions occur to states about 0.3 eV above the conduction band minimum, with a surprisingly narrow width of the absorption line. This seems to agree with calculations by M. Jaros (Univ. of Newcastle upon Tyne, UK) and seems to be related to the subsidiary minimum of the conduction band.

A new kind of size effect leading to resonant peaks in magnetoabsorption was described by R.A. Stradling (Clarendon Laboratory, Oxford, UK). To test the explanation of reported peaks in magnetoabsorption due to electron-hole droplets in Ga, these droplets were simulated by metallic NiSb rods in InSb. The rods are about 1 μm in diameter and randomly distributed; the difference in geometry between circular droplets and cylindrical rods is not important for demonstrating the existence of the effect. The observed oscillations of magnetoresistance as function of the magnetic field are caused by oscillations of the scattering potential in k-space.

The quick and economic deposition of thin films of a wide variety of semiconductor materials such as $Sm_{1-x}Yb_xS$, $SmS_{1-x}As_x$, $Sm_2S_3$, TmSe, YbTe, and $Zn_{1-x}Mg_xTe$ was discussed by R. Suryanarayanan (Centre National de la Recherche Scientifique, Bellevue, France). The films are made by multi-source evaporation. While the resulting films are polycrystalline, they usually allow good characterization of the materials by electrical and optical techniques.

D.W. Bullett (Cavendish Laboratory, Cambridge, UK) calculated the force constants of trigonal Se and Te by a local orbital approach starting from electronic wave functions of the free atoms. This gives reasonable agreement with experiment for the intra-chain properties. For interchain bonding, van der Waals forces have to be added. Some modes come out too soft because of the neglect of the dipole moments of the atoms.

A somewhat controversial presentation on "resonance" bremsstrahlung was given by H. Schwarz (Rensselaer Polytechnic Inst. and Univ. of Brazil). In 1971 he performed an experiment where a highly monochromatic (better than 10 meV) electron beam of 50 keV passes through an $SiO_2$ film and then strikes a nonfluorescent $Al_2O_3$ screen. Simultaneous illumination of the $SiO_2$ film with an Ar-laser beam, perpendicular to the electron beam and the electric field vector parallel to it, modulates the electron beam by the Ar-laser frequency. The $Al_2O_3$ screen acts as a demodulator and emits light at the Ar-laser frequency. For reasons which are not clear, nobody since has been able to repeat this experiment, not even Schwarz himself, who no longer has the original experimental equipment. (Alfred K. Nedoluha, USARSG)

## NEWS & NOTES

THE ODEILLO SOLAR POWER PLANT

On 25 January, the Solar Energy Laboratory of the Centre de la Recherche Scientifique in Odeillo (Pyrénées-Orientales) was officially inaugurated. This thermodynamic power plant, the first of its kind to supply current for the French national grid, has been coupled to the French utility since 19 November 1976. This is the first time in the world that power from the sun had been fed into a national grid. Since the

Odeillo plant is a low-power installation, its power is small (64 kW) and its yield limited (8%). It will be followed by other French and foreign experiments developing this new energy potential and proving its economic competitiveness.

RAYLEIGH MEDAL--L.M. BREKHOVSKIKH

At the Spring Conference of the Institute of Acoustics in Bath, UK in April, the President, Prof. E. Roland Dobbs, announced that the Institute's Rayleigh Medal for 1977 had been awarded to L.M. Brekhovskikh of the USSR. The medal is awarded annually to a person of undoubted renown for outstanding contributions to acoustics, and to a UK and a foreign acoustician alternately.

It is expected that the award will be made at the Institute's Spring Conference in 1978 now planned to be held at Cambridge.

At the University of Lancaster, the Department of Operational Research has set up a national simulation center which will act as a focal point for teaching and research in simulation activities. The center, which has been funded for three years by a grant from the Science Research Council, is under the direction of Professor Michael Simpson.

PERSONAL

Professor J.E. Baldwin, Professor of Chemistry, MIT, has been elected Waynflete Professor of Chemistry at Oxford University from 1 October 1978. He will succeed Sir Ewart Jones.

Dr. Sydney Brenner, FRS, Head of the Cell Biology Division of the Medical Research Council's Laboratory of Molecular Biology at Cambridge, is to succeed Dr. M.F. Perutz, FRS, as leader of the Laboratory on his retirement in 1979.

Dr. Francis Crick, FRS, Nobel Laureate, has left Britain to work in the US. He has been appointed Research Professor at a new center for the study of molecular biology which has been established under a grant to the Salk Institute for Biological Studies in San Diego, CA.

The following scientists have been appointed to professorships of the Royal Institution: Professor A. Hewish, FRS, Professor of Astronomy at Cambridge University; Sir Peter Medawar, FRS, Professor of Experimental Medicine, Medical Research Council; and Professor Charles Taylor, Professor of Experimental Physics, University College, Cardiff.

OBITUARIES

Professor Pehr Victor Edman, FRS, FAA, head of a department of the Max-Planck Institute for Biochemistry in Munich, died on 19 March at the age of 60.

Professor D.W. Holder, FRS, Head of the Department of Engineering Science, University of Oxford, died 18 April at the age of 54. He began his career in aeronautical research in 1943 at Boscombe Down, but soon joined the Aerodynamics Division of the National Physical Laboratory where he remained until 1961. While at NPL, he made many important contributions in the field of transonic aerodynamics and pioneered new testing techniques which are still in use. During this period, he published two books, four monographs, and over a hundred research papers. In 1961 he went to Oxford as Head of the Department of Engineering Science, where he remained until his sudden death. He was made a member of the Royal Society in 1962, and since 1969, served as a member of the Defence Scientific Advisory Council. He had been Visiting Professor in Ann Arbor, Stockholm and Delft.

Dr. Sheina Marshall, FRS, a well-known British marine biologist, died 7 April at the age of 81. Since 1922 she was associated with the Scottish Marine Biological Association at Millport, Isle of Cumbrae, where for many years she collaborated with Andrew P. Orr, a chemist. They produced a series of now classic joint researches on the annual cycle of marine productivity. In 1927, they joined the 13-month Great Barrier Reef Expedition in which they worked on plant and animal plankton and on the chemical and physical properties of the sea water. After years of research and a long series of papers, they published *The Biology of a Marine Copepod* in 1957. Later work was directed to the *Calanus*, using radioactive tracers. After Orr's death in 1962, Marshall collaborated

with Dr. E.D.S. Corder and others at the Marine Biological Laboratory in Plymouth. Almost every aspect of reproduction and metabolism of *Calanus* and other marine copepods were studied by her in her lifetime. After retiring in 1964, she continued her research and traveled to various laboratories throughout the world.

Professor A.D. Walsh, FRS, Dean of the Science Faculty and Head of the Department of Chemistry, University of Dundee, died 23 April at the age of 61. During his lifetime, he was interested in theoretical chemistry, particularly absorption spectroscopy of small molecules in the uv region, a product of which are the "Walsh Rules". He also was interested in combustion kinetics of gaseous systems. He joined Dundee in 1955 when he was appointed to the Baxter Chair of Chemistry in what was then St. Andrew's University, Queen's College, Dundee. In 1967 when Queen's College became the University of Dundee, Walsh was the obvious choice as Dean of the Science Faculty of the new university. He was highly regarded internationally.

## ONRL REPORTS

R-3-77

CLOSED CYCLE GAS TURBINE SYSTEMS IN EUROPE by S.C. Kuo and R.T. Schneider

A review on the status of closed cycle turbine research and development in Europe is given. Closed cycle turbines utilizing air as a working fluid, either coal, gas or oil fired have been used in the past for electricity generation and as additional sources for district heating. The newer developments employ helium as a working fluid. The gas is heated by a large sophisticated gas heater at present. However, the final intention is to use turbines in connection with the high temperature gas-cooled nuclear reactors. Marine applications for gas turbines exist and are discussed in the report.

R-4-77

COMMUNICATION ENGINEERING IN FINLAND by N.M. Blachman

The principal institution for electrical engineering education in Finland is the Helsinki University of Technology. The Technical Research Center of Finland is the leading organization in engineering research, and Nokia Electronics is the leading manufacturer of electronic equipment. This report discusses their activities--particularly in the field of communication engineering--and includes some remarks on the work going on elsewhere as well as on the general historical background.

C-41-76

VIIth INTERNATIONAL SYMPOSIUM ON MARINE MEDICINE, 23 THROUGH 30 SEPTEMBER 1976, ABOARD THE M/V BELLORUSSIYA by J. Vorosmarti

The VIIth International Symposium on Marine Medicine, sponsored by the USSR Ministry of Health, Research Institute of Water Transport, was held on the Black Sea on 23-30 September 1976. Presentations covered hygiene and epidemiology, chemical and physical factors on ships, clinical aspects of marine medicine, environmental hygiene and underwater medicine. This report reviews the diving medicine sessions specifically and the plenary sessions generally. Selected abstracts are included in the Appendix.

C-2-77

XIIIth INTERNATIONAL SEMICONDUCTORS CONFERENCE (1976) by P. Craig Taylor, T.L. Reinecke and B.D. McCombe

The major topics of this conference were generally the same as those emphasized at the two previous conferences (Stuttgart, 1974, and Warsaw, 1972). We review the following subjects which were of particular interest at this meeting: surfaces and interfaces, excitons and exciton condensation, disordered semiconductors, and future semiconductor devices. In addition, selected presentations concerned with impurities, lattice dynamics, band structure, and one- and two-dimensional systems are also summarized.

C-3-77

ELECTRICAL PHENOMENA IN BIOLOGICAL MEMBRANES: A SYMPOSIUM
by J.B. Bateman

This report provides a breakdown of topics considered at a symposium on "Electrical Phenomena at the Level of Biological Membranes" constituting the 29th International Meeting of the French "Société de Chimie Physique". The interdisciplinary nature of the symposium is illustrated by summarizing the proceedings in terms of "biological" and "non-viable" systems. The attempt is made to present the substance of the various contributions against a background that will make the report accessible to the general reader. It is suggested that the admirable goal of a truly interdisciplinary exchange was not achieved despite the evident efforts of some of the speakers to escape from the limitations of their own specialties.

C-4-77

CONFERENCE ON LUMINESCENCE PROCESSES IN CATHODE-RAY TUBES AND LAMPS, WEYBRIDGE, SURREY, ENGLAND, March 1977
by J.H. Schulman

This Europhysics Study Conference on phosphors dealt with inorganic impurity-activated phosphors used in cathode-ray tubes, fluorescent lamps, and x-ray screens. Most emphasis was given to the saturation effects in cathode-ray excitation of phosphors and the general problems of energy absorption, localization, transfer and emission in these phosphors.